(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 April 2011 (14.04.2011)

PCT

(10) International Publication Number
WO 2011/043703 A1

(51) International Patent Classification:
B60K 6/28 (2007.10) *H01M 10/50* (2006.01)
B60L 11/12 (2006.01)

(21) International Application Number:
PCT/SE2009/000442

(22) International Filing Date:
9 October 2009 (09.10.2009)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant *(for all designated States except US)*: **VOLVO LASTVAGNAR AB** [SE/SE]; S-405 08 Göteborg (SE).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **AXELSSON, Tobias** [SE/SE]; Landalagangen 7, S-411 30 Göteborg (SE). **MOUDEN, Guy** [FR/FR]; 7, Impasse Thibaude, F-69800 Saint Priest (FR). **LARSSON, Johan** [SE/SE]; Snickarevägen 11, S-444 30 Stenungsund (SE). **LENNEVI, Jerker** [SE/SE]; Svedernavägen 18, S-443 92 Lerum (SE).

(74) Agent: **FRÖHLING, Werner**; Volvo Technology Corporation, Corporate Patents, 06820, M1.7, S-405 08 Göteborg (SE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: APPARATUS AND METHOD FOR CONTROLLING THE TEMPERATURE OF A BATTERY IN A HYBRID ELECTRIC VEHICLE

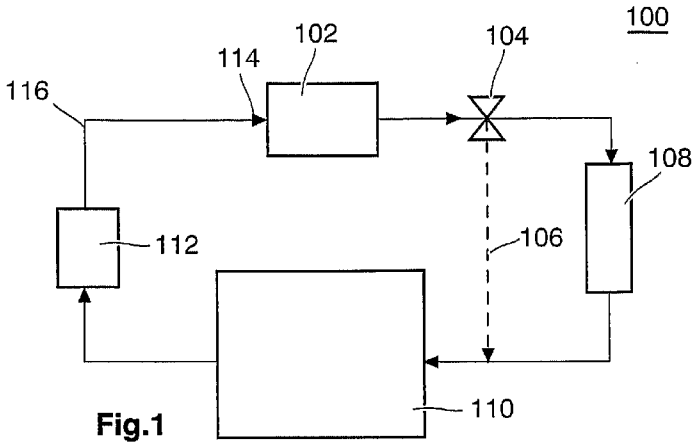

Fig.1

(57) Abstract: The present invention relates to a method for controlling the temperature of a traction battery in a hybrid vehicle, where said hybrid vehicle comprises an internal combustion engine and an electric motor for traction power, comprising the steps of: providing a first temperature regulating circuit for the internal combustion engine, providing a second temperature regulating circuit for the traction battery, heating the traction battery by an electrical heater provided in said second temperature regulating circuit in series with a pump, a radiator and said traction battery, transferring power to said heater via a DC/DC converter in said second temperature regulating circuit from the electrical motor, which electrical motor is driven by said internal combustion engine, while said battery is below a predetermined temperature interval.

WO 2011/043703 A1

DESCRIPTION

Apparatus and method for controlling the temperature of a battery in a Hybrid Electric Vehicle.

TECHNICAL FIELD

The invention relates to a hybrid vehicle battery temperature control method and apparatus according to the preambles of the independent claims.

BACKGROUND OF THE INVENTION

Hybrid electric vehicles comprise an internal combustion engine and an electric machine. The electric machine is supplied with traction power at least partly from a battery.

It is known that temperature has an influence over battery performance. As the battery is being charged, the temperature of the battery may increase due to a chemical reaction of the battery solution. The temperature increase during charging may accelerate corrosion and degradation of the positive electrode. Therefore, a too high temperature of the battery may lower its performance and shorten its lifetime. Similarly, a too low temperature of the battery may also decrease its performance and lifetime. A desired operating temperature for a lead acid battery is 25°C -40°C while a lithium ion battery may have a desired operating temperature range of 0°C-40°C.

In view of the above it is desired to control the temperature of the battery in a hybrid vehicle in order to extend the lifetime of the battery.

In US 7147071 it is disclosed a hybrid electrical vehicle with a battery temperature regulating device. The device comprises an internal combustion engine coolant circuit and a battery coolant circuit. Heat is transferred between the circuits via a heat exchanger.

A problem with the solution proposed in US 7147071 is the high cost for the heat exchanger and that the coolant circuit for the engine must be redesigned.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a method for controlling the temperature of a traction battery in a hybrid vehicle which overcomes the above mentioned problems.

The objects are achieved by the features of the independent claims. The other claims and the description disclose advantageous embodiments of the invention.

In a first example embodiment according to the invention it is provided a method for controlling the temperature of a traction battery in a hybrid vehicle, where said hybrid vehicle comprises an internal combustion engine and an electric motor for traction power, comprising the steps of: providing a first temperature regulating circuit for the internal combustion engine, providing a second temperature regulating circuit for the traction battery, heating the traction battery by an electrical heater provided in said second temperature regulating circuit in series with a pump, a radiator and said traction battery, transferring power to said heater via a DC/DC converter in said second temperature regulating circuit from the electrical motor, which electrical motor is driven by said internal combustion engine, while said battery is below a predetermined temperature interval.

An advantage with this example embodiment is that the power for heating the battery is provided from the internal combustion engine via a DC/DC converter and said electrical motor.

In another example embodiment according to the present invention said method further comprising the step of using said battery for traction power only when said battery has a temperature within said predetermined temperature interval.

An advantage with this example embodiment is that the lifetime of the battery may be extended.

In another example embodiment according to the present invention said method further comprising the steps of providing a bypass circuit for said radiator in said second temperature regulating circuit, regulating a flow of liquid coolant into the radiator or into the bypass circuit by a valve.

An advantage with this example embodiment is that the time for reaching a working temperature of the battery may be decreased.

In another example embodiment of the present invention said method further comprising the step of: controlling said electric motor by a voltage target value for feeding power to the heater when said battery is below said predetermined temperature interval.

An advantage with this embodiment is that the electrical components life time may be increased and its performance may be secured.

In another example embodiment according to the present invention said method further comprising the step of: isolating said second temperature regulating circuit from said first temperature regulating circuit.

An advantage of this example embodiment is that the first end second temperature regulating circuits can be controlled independently of each other.

The invention also relates to a system for controlling the temperature of a traction battery in a hybrid vehicle, where said hybrid vehicle comprises an internal combustion engine and an electric motor for traction power, said system comprising: a first temperature regulating circuit for the internal combustion engine, a second temperature regulating circuit for the traction battery, a heater, a pump and a radiator provided in said second temperature regulating circuit, said heater is provided with power via a DC/DC converter from the electrical motor, which electrical motor is driven by said internal combustion engine.

An advantage with this example embodiment is that the power for heating the battery is provided from the internal combustion engine via a DC/DC converter and said electrical motor.

In another example embodiment of the present invention said system further comprising a bypass circuit for said radiator in said second temperature regulating circuit, a valve for regulating a flow of liquid coolant into the radiator or into the bypass circuit.

An advantage with this example embodiment is that the time for reaching a working temperature of the battery may be decreased.

In yet another example embodiment according to the present invention said system further comprising a controller for controlling said electric motor by a voltage target value for feeding power to the heater when said battery is below said predetermined temperature interval.

An advantage with this embodiment is that the electrical components life time may be increased and its performance may be secured.

In still another example embodiment of the present invention said first and second temperature regulating circuits are isolated from each other.

An advantage of this example embodiment is that the first end second temperature regulating circuits can be controlled independently of each other.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention together with the above-mentioned and other objects and advantages may best be understood from the following detailed description of the embodiments, but not restricted to the embodiments, wherein is shown schematically:

Fig. 1 depicts a schematic representation of an example embodiment of a temperature regulating circuit for regulating a temperature of a traction battery in a hybrid vehicle according to the present invention

Fig, 2 depicts a schematic representation of a parallel hybrid vehicle according to an example embodiment according to the present invention.

In the drawings, equal or similar elements are referred to by equal reference numerals. The drawings are merely schematic representations, not intended to portray specific parameters of the invention. Moreover, the drawings are intended to depict only typical embodiments of the invention and therefore should not be considered as limiting the scope of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Figure 1 depicts an example embodiment of a temperature regulating circuit 100 for regulating a temperature of a traction battery in a hybrid vehicle according to the present invention. Said temperature regulating circuit 100 comprises a heater 102, an optional valve 104, an optional by pass liquid coolant circuit 106, a radiator 108, a traction battery 110, a pump 112 and a main liquid coolant circuit 116.

In the main temperature regulating circuit 116 (solid lines in figure 1) a liquid coolant is transportable with the help of the pump 112. The liquid coolant may be water blended with ethylene glycol, ammonia, dichlorodifluoroethane, or any other suitable liquid coolant. The pump 112 may be electrically driven and/or driven by a belt or hydraulically from an internal combustion engine. Liquid coolant is transported by the pump 112 to the heater 102. Said heater is an electric heater which uses the same line voltage as the other electric equipment in the vehicle, which line voltage is usually 24 V for trucks, busses and construction equipments and 12V for passenger cars.

Liquid coolant is transported from the heater 102 to the radiator or a heat exchanger 108. Said heat exchanger 108 may be equipped with a fan for transporting away heat from the heat exchanger 108. Alternatively no fan is used which means that only wind speed or the environmental temperature difference is used to cool off the heat exchanger 108.

Liquid coolant is transported from the heat exchanger 108 to the traction battery 110 and then back to the pump 112. The traction battery 110 may have a line voltage of 400V, 600V or any other suitable line voltage. Said traction battery may be of the lead acid type, lithium-ion type, nickel metal hydride type or any other suitable battery type.
In figure 1 it is also illustrated an optional by pass liquid coolant circuit 106 (dashed line) together with a valve 104. The valve may be used to bypass the radiator 108. The radiator 108 may be bypassed when heating the traction battery 110 to a suitable temperature, which will speed up the time required for the battery to reach said suitable temperature compared to when the liquid coolant is forced to pass through the radiator 108.

In figure 2 it is illustrated a schematic representation of a parallel hybrid vehicle 200 according to an example embodiment according to the present invention. Said parallel hybrid vehicle comprises an internal combustion engine 228, a transmission 227, en electric machine 226, a DC/DC converter 229, the traction battery 210, a switch 224 and said heater 202.

The internal combustion engine 228 may be a diesel engine, a gasoline engine or a multi fuel engine. The transmission 227 comprises mechanical connection between the internal combustion engine 228 and the electric machine 226. Said transmission may inter alia comprise a clutch, a gear box, drive shaft etc. The electric machine 226 has a dual functionality, providing torque or power to the transmission for propelling the vehicle, i.e., as a motor, or in the reverse direction during regeneration, for instance when the vehicle is braking, converting mechanical energy from the wheels into electrical energy, i.e., as a generator. The regeneration may also be performed in combination with the internal combustion engine for delivering charging current to the battery.

The electric machine may be of AC type or DC type of known alternative configurations which is well known in the art and therefore need no further explanation in this context.

The DC/DC converter is used to transform the voltage generated from the battery and/or the electric machine, which is usually in the range of several hundreds of volts, to a suitable line voltage for all the electrical equipment in the vehicle which is usually in the range of 6-50 volts. The DC/DC converter is arranged between the electrical machine/traction battery and the electrical system in the vehicle comprising for instance the heater 202, radio, internal combustion engine management system, bulbs, electronics etc.

The traction battery is arranged in the hybrid vehicle 200 via a switch 224. Said switch may be used for different purposes. Firstly it may be a security switch for disconnecting the high voltage provided from the battery to the hybrid vehicle and secondly it may be used when in the charging management strategy for said battery.

A first temperature regulating circuit may be used for the internal combustion engine. A second temperature regulating circuit 100 may be used for the traction battery. The traction battery may be heated by an electrical heater 102 provided in said second temperature regulating circuit 100 in series with a pump 112, a radiator 108 and said traction battery 110. Power may be transferred to said heater via a DC/DC converter 229 in said second temperature regulating circuit 100 from the electrical motor 226, which electrical motor 226 may be driven by said internal combustion engine 228, while said battery 210 is below a predetermined temperature interval.

During the heating of the battery 210 said battery 210 may be disconnected by opening the switch 224. The electrical motor 226 may generate a high electric voltage in the range of 300-800V. The DC//DC converter may convert said high electric voltage to an electric voltage in the range of 6-50V. When the battery is cold the valve 104 may be set so that liquid coolant is bypassed the radiator 108.

This may increase the efficiency and reduce the warm up period for the battery 110, 210. When the battery is warm enough, i.e., within a temperature range that is specific for the type of battery used, said switch 224 is closed so that the battery is connected for giving traction power to the vehicle. By ensuring that the battery is having a temperature within said temperature interval, the battery may be used without violating the life time of the battery. When the switch is closed and the battery is used for traction power its temperature may still be regulated by the temperature regulating circuit for ensuring as long as possible life time of the battery, i.e., the heater 102, 202 may be active while the battery is providing traction power to the electrical motor. While the battery is heated (and disconnected) said electrical motor is voltage controlled, i.e., a voltage range is predetermined for ensuring that sufficient and not too much voltage is delivered to the electrical components while the battery is disconnected. The electrical motor is working as a regulator, braking or not braking, for keeping the system voltage within said predetermined voltage range. When the battery is connected one is instead regulating the current in and out from the battery in a manner well known in the art.

The battery is only used, i.e., providing traction power to the vehicle via the electrical motor, when the temperature of the battery is within a given temperature interval, which is specific for the type of battery used. Said temperature interval for the battery can be found in the technical date for the battery type used.

The above disclosed invention is described with a parallel hybrid vehicle. With appropriate amendment o the setup the present invention is equally applicable for a serial hybrid vehicle.

It is to be understood that the present invention is not limited to the embodiments described above and illustrated in the drawings; rather, the skilled person will recognize that many changes and modifications may be made within the scope of the appended claims.

CLAIMS

1. A method for controlling the temperature of a traction battery in a hybrid vehicle, where said hybrid vehicle comprises an internal combustion engine and an electric motor for traction power, comprising the steps of:
   a. providing a first temperature regulating circuit for the internal combustion engine,
   b. providing a second temperature regulating circuit for the traction battery
   c. heating the traction battery by an electrical heater provided in said second temperature regulating circuit in series with a pump, a radiator and said traction battery,

   characterized in that said method further comprising the step of:

   d. transferring power to said heater via a DC/DC converter in said second temperature regulating circuit from the electrical motor, which electrical motor is driven by said internal combustion engine, while said battery is below a predetermined temperature interval.

2. The method according to claim 1, further comprising the step of:
   e. using said battery for traction power only when said battery has a temperature within said predetermined temperature interval.

3. The method according to claim 1 or 2, further comprising the steps of:
   f. providing a bypass circuit for said radiator in said second temperature regulating circuit,
   g. regulating a flow of liquid coolant into the radiator or into the bypass circuit by a valve.

4. The method according to any one of the preceding claims, further comprising the step of:
   h. controlling said electric motor by a voltage target value for feeding power to the heater when said battery is below said predetermined temperature interval.

5. The method according any one of the preceding claims, further comprising the step of:

i. isolating said second temperature regulating circuit from said first temperature regulating circuit.

6. A system for controlling the temperature of a traction battery in a hybrid vehicle, where said hybrid vehicle comprises an internal combustion engine and an electric motor for traction power, said system comprising:

a first temperature regulating circuit for the internal combustion engine,

a second temperature regulating circuit for the traction battery,

a heater, a pump and a radiator provided in said second temperature regulating circuit, characterized in that said heater is provided with power via a DC/DC converter from the electrical motor, which electrical motor is driven by said internal combustion engine.

7. The system according to claim 6, further comprising:

a bypass circuit for said radiator in said second temperature regulating circuit,

a valve for regulating a flow of liquid coolant into the radiator or into the bypass circuit.

8. The system according to claim 6, further comprising:

a controller for controlling said electric motor by a voltage target value for feeding power to the heater when said battery is below said predetermined temperature interval.

9. The system according to claim 6, wherein said first and second temperature regulating circuits are isolated from each other.

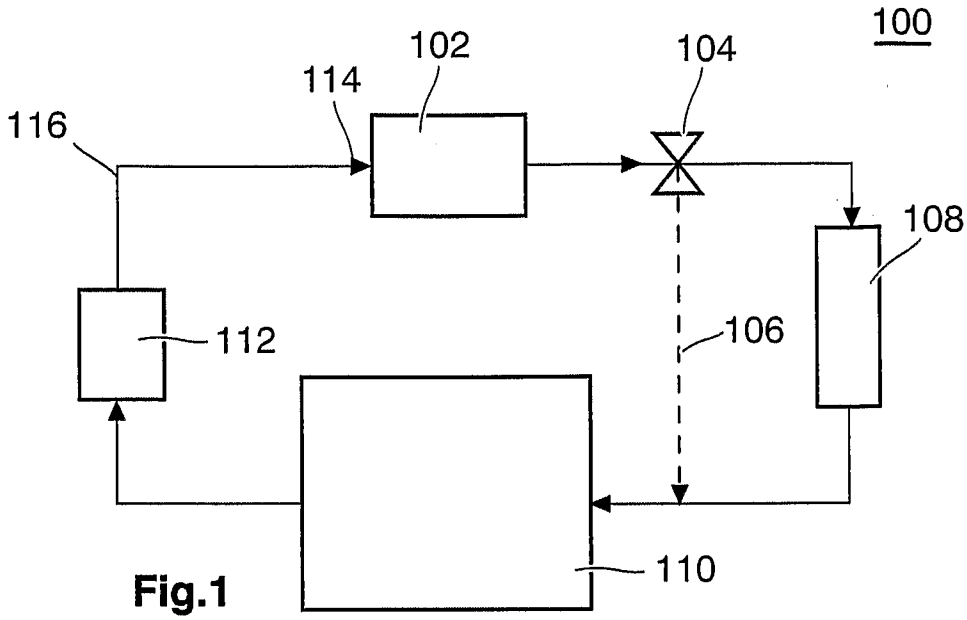
100
102
104
114
116
108
112
106
110

Fig.1

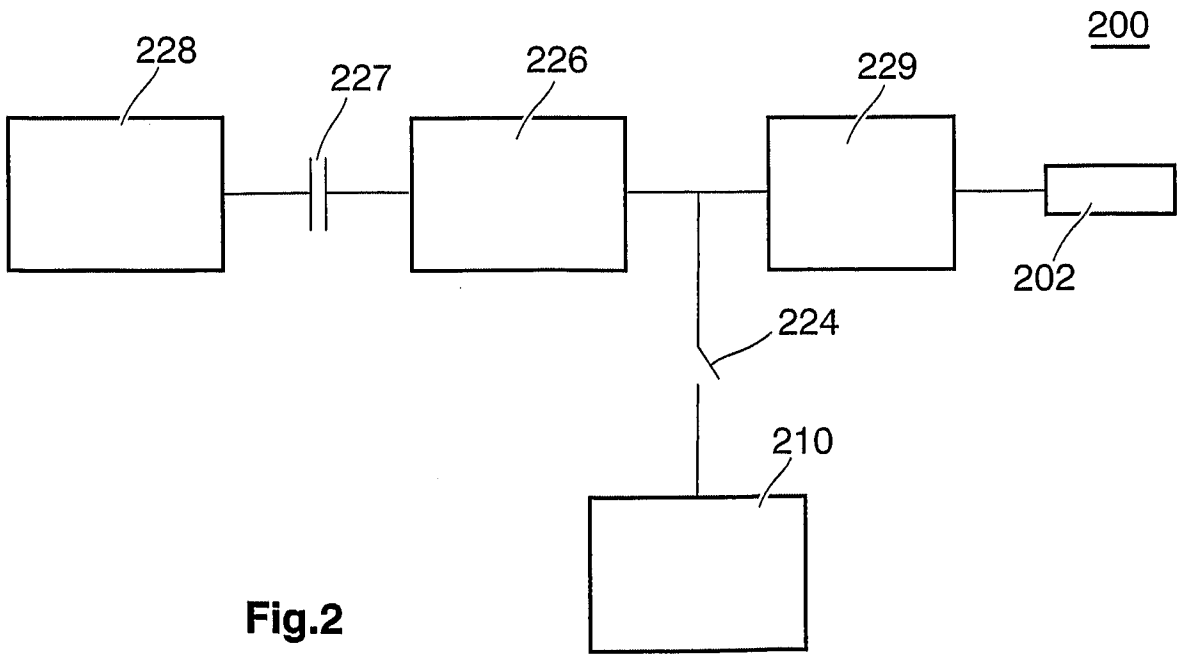
200
228
227
226
229
202
224
210

Fig.2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2009/000442

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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)

IPC: B60K, B60L, H01M

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

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20090249807 A1 (M.D. NEMESH ET AL), 8 October 2009 (08.10.2009), figure 1, paragraphs (0003), (0013)-(0014), (0019)-(0020)	1-9
A	US 7147971 B2 (GERING ET AL), 12 December 2006 (12.12.2006), abstract	1-9
A	US 6575258 B1 (S.L. CLEMMER), 10 June 2003 (10.06.2003), abstract	1-9
A	US 20070210769 A1 (M. TSUTSUMI ET AL), 13 Sept 2007 (13.09.2007), paragraphs (0056), (0058)	1-9

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 June 2010	22-06-2010
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Tomas Erlandsson / MRo Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 2009)

International patent classification (IPC)

B60K 6/28 (2007.10)
B60L 11/12 (2006.01)
H01M 10/50 (2006.01)

Download your patent documents at www.prv.se
The cited patent documents can be downloaded:

- From "Cited documents" found under our online services at www.prv.se (English version)
- From "Anförda dokument" found under "e-tjänster" at www.prv.se (Swedish version)

Use the application number as username. The password is **VDGILQILQQ**.

Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85).

Cited literature, if any, will be enclosed in paper form.

US	20090249807	A1	08/10/2009	NONE			
US	7147971	B2	12/12/2006	US	20030027050	A	06/02/2003
US	6575258	B1	10/06/2003	NONE			
US	20070210769	A1	13/09/2007	NONE			