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(54) **Method and apparatus for indicating a state of health of a battery**

(57) The invention relates to a method and apparatus for determining a state of health of a battery in a vehicle comprising determining (201) a state of charge of the battery; determining (202) a battery temperature and a cranking temperature; obtaining (204) a cranking signal from the battery when the battery is discharged during cranking of a combustion engine of the vehicle; determining (205) one or more cranking type classes based on the determined battery temperature and the determined cranking temperature; determining (206) battery parameters from the cranking signal; determining (207) the state of health of the battery from the battery parameters, a vehicle identifier and historical battery parameters determined in a historic state preceding the current state; and outputting (206) the state of health. In this way a reliable indication can be obtained from the state of health of the battery in the vehicle.

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Method and apparatus for indicating a state of health of a battery

Field of the invention

The present invention relates to a method and device for indicating a state of health of a battery in a vehicle. In general, batteries are applied in vehicle for cranking a combustion engine.

Background art

Battery technology comprises a combination of chemistry, material, mechanical and electrical science. An aggregation of these technologies yields to a small electrical-energy producing device, referred to as a battery. In the automotive sector lead acid batteries are used in cranking applications.

The state of health, SOH, of lead acid batteries is decreasing with age revealing a reduced battery performance. The performance of lead acid batteries is expressed in capacity and peak power delivery.

The effective performance and therefore the SOH of the battery is gradually decreasing until a cranking failure manifests itself. Batteries can have different failure modes caused by a combination of underlying failure mechanisms. A battery is a closed system and progressing failure mechanisms cannot be observed without the use of invasive methods i.e. to really reveal the battery's SOH the casing has to be opened enabling the internals to be examined which will destroy the battery. Most failures are caused by a combination of different failure mechanisms. Using a non-invasive SOH estimator groups all progressing failure mechanisms together, but enables the SOH to be estimated without destroying the battery. Conventionally, non-invasive SOH estimators are based on the effective capacity and internal resistance of the battery.

A method and apparatus for indicating a state of health of a battery is known from US20130046435. A starting system for an internal combustion engine includes a starter motor and a battery. A method for evaluating the starting system includes detecting a fault associated with the starter motor when a minimum starting system voltage during a cranking event is greater than a threshold minimum starting system voltage determined in relation to an engine acceleration parameter, and detecting a fault associated with the battery when the engine acceleration parameter is less than a minimum threshold for the engine acceleration parameter.

A drawback of the known device and method is that the indication is not reliable.

Therefore, there is a need to provide a more efficient method and a device estimating the state of health of the battery.

Summary of the invention

According to a first aspect, the invention provides a method for determining a state of health of a battery in a vehicle comprising the steps of

a) determining a state of charge of the battery;

b) determining a battery temperature;

c) determining a cranking temperature;

d) obtaining a cranking signal from the battery when the battery is discharged during cranking of a combustion engine of the vehicle;

e) determining one or more a cranking type classes based on the determined battery temperature and the determined cranking temperature;

f) determining battery parameters from the cranking signal corresponding to the determined one or more cranking classes;

g) determining the state of health of the battery for at least one or more cranking type classes from the battery parameters corresponding to the cranking type class in a current state, a vehicle identifier and historical battery parameters corresponding to the one or more cranking type classes determined in a historic state preceding the current state; and outputting the state of health.

According to the present invention, a method for determining a state of health as defined above is provided, in which the method non-invasive measuring of the cranking signal can be applied. For example, a standardized connection implemented in all European vehicles since 2002 can provide a cranking signal of the battery of the vehicle at a number of instants and during cranking. The cranking signal can be a digital signal obtained via the standardised connection.

The state of charge of the battery can be used to decide whether to continue or to discontinue the present method depending on the obtained state of charge, because it does not make sense to determine the state of health for a discharged or partly discharged battery. The battery temperature can be based on the temperatures provided by an engine management system via the standardized connection directly after a cranking event. For example, an engine coolant temperature, ambient temperature, device temperature; duration of last operation of the combustion engine and time elapsed since the last operation.

The cranking temperature can be based on the engine coolant temperature, the ambient temperature, the device temperature and the time elapsed since the last trip.

The inventors have acknowledged a high correlation between the voltage values of the battery, the temperature of the engine of the vehicle and the battery. Different cranking type classes can be distinguished based on the determined battery temperature and the cranking temperature. By distinguishing different cranking type classes the estimation of the battery state can be further improved. The battery parameters determined from the cranking signal corresponding to the cranking type class and a vehicle identifier has proven to be reliable state parameters of the battery and enables a reliable determination of the state of health of the battery. The determined state of health can be displayed or a warning signal can be generated.

According to an embodiment the historical state of the battery is an initial state of the battery. The initial state can be the state of a new or fresh battery when directly installed in the vehicle.

According to an embodiment the step of determining the state of health comprises performing a normalized field method on the battery parameters in the initial state and the current state for the determined cranking type class for a certain vehicle identified by the vehicle identifier. The normalized field method is used to determine an area based on a combination of the battery

parameters indicating a healthy state of the battery or an area indicating a poor state of the battery. The inventors has realized that this method takes advantage of the interdependency between the battery parameters.

According to a still further embodiment determining the battery parameters for the cranking type class in the initial state comprises:

- measuring battery parameters measured after each of a plurality of consecutive crank periods;
- determining the battery parameters based on an average of the measured battery parameters. By repeating, in the initial state, these steps the battery parameters corresponding to a set of cranking type classes in the initial state can be obtained.

In the normalized field method a normalized value can be obtained by using the quotient of the battery parameters in the current state and the battery parameter in the reference state and by selecting two battery parameters from the set of battery parameters and defining a line in the parameter field defined by the selected battery parameters. The battery parameters can be an initial voltage, IV, a lowest voltage value, LVV, and a mean cranking voltage, MCV. These parameters have proven to be the most promising for estimating the state of health of the battery.

According a still different embodiment the step of determining the state of health comprises

-determining a moving window average of the historical battery parameter of a plurality of historic states in the cranking type class;

-determining a scaled battery parameter based on the battery parameter determined at the current state and the determined moving window average of the historical battery parameter in the cranking type class;

- determining the state of health at the current state from the scaled battery parameters.

This method provides a simple method for determining the state of health of the battery. The moving average can be determined over a certain period, for example 20 historic states of the battery state before a predetermined period, for example 10 historic states, from the current state in a cranking type class. The battery parameters can be the lowest voltage value and the mean cranking voltage.

According to a further embodiment determining the state of charge of the battery comprises

-determining, after a resting period of the combustion engine, a resting voltage of the battery;

-determining a reference value for the resting voltage;

-measuring the resting voltage of the battery in the current state after an operating period of the combustion engine;

-determining the state of charge of the battery based on the reference resting voltage value, the measured resting value and the operating period;

-deciding to continue or discontinue the determination of the state of health of the battery depending of the state of charge of the battery. In this way a state of charge can be determined after a resting period of the battery after an operation period of the vehicle. This steps prevents performing the further steps of the method when the state of charge of the battery is insufficient, for example when the battery is not recharged completely after a short operation or short trip of the vehicle.

According to a further embodiment the battery temperature is based on an engine coolant temperature, ambient temperature, device temperature; duration of last operation of the combustion

engine and time elapsed since the last operation. In this way a more reliable estimation of the battery temperature can be obtained.

According to a still further embodiment the cranking temperature is based on the engine coolant temperature, the ambient temperature, the device temperature and the time elapsed since the last trip.

According to a second aspect, the invention provides a device for determining a state of health of a battery in a vehicle comprising

a storage device, an input device, an output device comprising a display, a communication device arranged to communicate to a control system of the vehicle; and a controller arranged to

a) determine a state of charge of the battery;

b) determine a battery temperature;

c) determine a cranking temperature;

d) obtaining a cranking signal from the battery when the battery is discharged during a crank of a combustion engine of the vehicle;

e) determine one or more cranking type classes based on the determined battery temperature and the cranking temperature;

f) determine battery parameters from the cranking signal corresponding to the one or more cranking type classes;

g) determine the state of health of the battery for at least one or more cranking type classes, from the battery parameters determined corresponding to the cranking type class in a current state, a vehicle identifier and historical battery parameters corresponding to the one or more cranking type classes determined in a historic state preceding the current state; and

h) output the state of health through the output device.

According to a third aspect, the invention provides a computer program product comprising computer program code means adapted to perform all the steps of any one of the method claims 1 to 11 when the computer program is run on a computer 1 - 11.

Short description of drawings

The present invention will be discussed in more detail below, with reference to the attached drawings, in which

Fig. 1 shows an embodiment of an apparatus for determining a state of health of a battery;

Fig. 2 shows a flow diagram of an embodiment of the method;

Fig. 3 shows a flow diagram of an embodiment of the method to determine a cranking signal;

Fig. 4 shows a flow diagram of an embodiment of the method to determine battery parameters from the filtered cranking signal;

Fig. 5 shows a flow diagram of a first embodiment of the method to determine a state of health from the battery parameters;

Fig. 6 shows a graphical representation of a two-dimensional normalized parameter field;

Fig. 7 shows a flow diagram of a second embodiment of the method for determining a state of health from the battery parameters;

Fig. 8 shows a graphical representation of a two-dimensional non-scaled parameter field; and

Fig. 9 shows a graphical representation of a cranking signal.

Description of embodiments

Fig. 1 is a block diagram of an internal structure of a device 10 or system comprising a user's computer in accordance with an exemplary embodiment of the present invention for determining a state of health of a battery 2 in a vehicle 1. The vehicle is provided with an engine 3 including a crank unit, a battery 2, an engine management system 4 and a vehicle communication device 5. The vehicle communication device 5 may comprise an on board diagnostic, device, OBD. The OBD can be connected via a Bluetooth or Wi-Fi device to the device 10.

The device 10 can be a personal computer, a smartphone, laptop or any other type of microprocessor based device. The device 10 may comprise a processor 11, an input device 12, a storage device 13, the storage device 13 can be a temporary storage device or permanent storage device and a first communication device 15 for connecting to the OBD 5. The first communication device 15 may include a modem, network interface card, or any other device able to transmit and receive signals to the vehicle communication device 5, for example Bluetooth or Wi-Fi. The input device 12 can be a key board, mouse, pen operated device and any other input device that provides input from a user. The device can further comprise a second communication device 16 and an output device 14. The second communication device 16 may include a modem, network interface card, or any other device able to communicate to the server 18 via the Internet 17. The output device 14 may be a monitor, speakers, printer or any other device that provides tangible output to a user. The temporary storage device may include RAM, caches, and any other volatile storage medium that temporarily holds data while processing it. The permanent storage device may include a solid state drive, hard drive, CD-ROM drive, tape drive, removable storage disk, or any other nonvolatile data storage medium. The temporality and permanent storage devices can store one or more of the determined parameters and values obtained during operation of the methods, described hereinafter.

Fig. 2 shows a flow diagram according to an embodiment of the method for determining a state of health of the battery. In step 201 a state of charge of the battery is determined. According to an embodiment the state of charge can be determined by obtaining the open circuit voltage, OCV, of the battery after a predetermined rest period, wherein the vehicle is shut down and parked. The rest period can be for example 30 minutes. The thus obtained value proves to be a more accurate estimate of the OCV. The obtained value of the open circuit voltage is hereinafter called the rest value, RV. The RV is unique for a battery-vehicle combination. From the RV value a reference value can be obtained. A deviation from the reference value may indicate an insufficient state of charge of the battery.

Alternatively, according to an embodiment determining the state of charge of the battery may comprise the substeps of:

Measuring the values of the resting voltage of the battery at plurality of instants at a fixed time interval in an initial state and a current state.

Determining a derivative from the plurality of measured values in the initial state and the current state.

Determining a resting voltage derivative deviation based on the derivatives of the measured values in the initial state and the derivatives of the measured values in the current state;

wherein the determining the state of charge is based on the resting voltage derivative deviations.

According to an embodiment the method of determining the state of health can be discontinued and a message can be output on the display 14, when the determined state of charge of the battery is poor and a reliable state of health of the battery cannot be obtained.

In step 202 a battery temperature can be obtained. According to an embodiment the battery temperature is based on a combination of the engine coolant temperature, ambient temperature, device temperature a duration of last operation of a combustion engine, and time elapsed since last trip. These values can be obtained from the engine management unit via the communication interface and/or the OBD 5.

In step 203 a cranking temperature can be determined based on the engine coolant temperature, the ambient temperature, the device temperature and the time elapsed since the last trip. These values can also be obtained from the engine management unit via the communication interface and/or the OBD 5.

In step 204 a cranking signal can be a digital signal obtained during a cranking period by sampling the voltage of the battery, when the battery is discharged by the crank unit during one or more revolutions of the crank unit in the combustion engine during the cranking period. The cranking period is for example 1 sec. The sample frequency can be for example 200 Hz. So, according to this embodiment the cranking signal comprises 200 samples. The cranking signal can also be obtained from the communication device and/or the OBD.

In step 205 one or more cranking type classes of the battery are determined based on the determined battery temperature and the determined cranking temperature. The advantage of using cranking type classes is that the inventors recognized that the cranking type classes may define sets of reference battery parameters that are specific for each vehicle, the battery temperature and cranking temperature. The cranking type classes can be selected on basis of the determined battery temperature and determined cranking temperature. The number of cranking type classes can be for example 17.

In step 206 the battery parameters, for example the lowest voltage value, LVV, and the mean cranking voltage, MCV are obtained from the cranking signals corresponding to one or more cranking type classes.

According to an embodiment the step of determining the battery parameters for the one or more cranking type classes in the initial state comprises determining battery parameters after each of a

plurality of consecutive crank periods from the cranking signals; and determining the battery parameters based on an average of the measured battery parameters. These steps can be repeated for the all the cranking type classes.

According to an embodiment the step of determining battery parameters from the obtained cranking signal comprises the substeps of determining a filtered cranking signal from the cranking signal and determining the battery parameters from the filtered cranking signal.

Fig 3 shows a flow diagram of an embodiment method to determine a filtered cranking signal from the cranking signal. In this description the cranking signal comprises N samples 1..N.

The substeps for obtaining the filtered cranking signal from the cranking signal comprising:

- Determining (301) a minimum (X, a) in the cranking signal; wherein X represents number of the sample in the cranking signal and a represents a value of the sample.
- Determining (302) a maximum (Y, b) in the cranking signal, wherein Y represents the sample number and satisfies 1< Y< X and b represents the value b of the sample;
- Determining (303) a point (Z, c), wherein Z represents a sample number between X and N in the cranking signal that corresponds to the number of the sample which value c equals 0.9 b.
- Determining (304) an intermediate cranking signal of the samples Y to Z of the cranking signal. The resulting intermediate cranking signal is the result of a window function applied on the cranking signal.
- Splitting (305) the Z – Y samples of the intermediate cranking signal in a first part of samples Y to X and a second part of samples X to Z.
- Filtering (306) the first part by a first digital filter and the second part by a second digital filter. In an embodiment the digital filters can be a Saviki-Golay filter, as is well-known for the skilled person, in the respective Saviki-Golay filter the frame length and polynomial order can be differently selected depending on the variation of the values in the first and second part of the intermediate cranking signal.
- Determining (307) the filtered cranking signal by concatenating the filtered second part after the filtered first part.

Fig. 9 shows a graphical representation of the cranking signal. In the graph (X,a) represents a minimum of the cranking signal 90, (Y,b) represents a maximum of the cranking signal, and (Z,c) represents a value c of sample Z, which sample number is determined between X and N in the cranking signal such that the value c equals 0.9 b.

Fig. 4 shows a flow diagram of an embodiment of the method to determine battery parameters from the filtered cranking signal. The substeps to determine the battery parameters comprises:

Firstly determining a parameter crankEnd by the substeps:

- Determining (401) local minima and local maxima in the filtered cranking signal.
- Determining (402) the local maximum (K, Max_{local}) having the highest sample number K from the local maxima.
- Determining (403) the crankEnd as the sample number S corresponding to a sample (S, d) in the filtered cranking signal wherein S is between K and Z and d equals Max_{local}.

-determining at least one or more of the determined local maxima (i,max_i) for which the sample number i is smaller than X. This number can be for example 3.

-determining (404) the initial value, IV, from the average of the one or more determined local maxima max_i values.

- Determining (405) the lowestValleyVoltage, LVV as the lowest local minimum (L, Minlocal) from the filtered cranking signal.

And determining (406) the mean cranking voltage, MCV, by averaging the values s_m of the samples L to S, so the values of the sample of the filtered signal between the sample number between the lowestVallyeVoltage and the sample number S corresponding the crankEnd or

$$MCV = \frac{1}{M}\sum_{m=L}^{M=Z}(s_m, m)$$

Wherein M represents the number of samples determined by S-L.

In this way the filtered cranking signal with a user independent crank end can be determined.

According to an embodiment the state of health of the battery can be based on a comparison of the battery parameters IV, LVV, MCV in a historic or initial state and the determined parameters IV, LVV and MCV in the current state for the different cranking type classes from the filtered cranking signal. The determined values of these battery parameters can be stored in a table or database in a local memory 13 of the device 10 or in the data base server 18 which can be accessed by the device 10 through the Internet 17.

An example of battery parameters IV, LVV and MCV are listed in table 1 for 17 cranking type classes.

Table 1 table of cranking type classes and batteryparameters

crankingTypeClass	completed	IV	MCV	LVV
H1	FALSE			
H2	FALSE			
H3	FALSE			
H4	FALSE	12,17	9,79	8,03
H5	FALSE			
W1	FALSE			
W2	FALSE			
W3	FALSE	12,17	9,92	8,07
W4	TRUE	12,18	9,88	8,13
W5	FALSE			
C1	FALSE			
C2	FALSE	11,93	9,68	7,51
C3	TRUE	11,97	9,46	7,81
C4	TRUE	12,04	9,74	7,92
C5	FALSE			
N1	FALSE	12,13	8,05	9,81
etc.				

The values for IV, MCV and LVV in Table 1 can be stored and updated in the data base after the cranking events in the corresponding cranking type class.

Fig. 5 shows a flow diagram of a first embodiment of the method to determine a state of health from the battery parameters. According to this embodiment the step of determining the state of health of the battery comprises the substeps:

- Determining (501) for the at least one or more cranking type classes the battery parameters at an initial state of the battery for the at least one or more cranking type classes according to steps 200-204.
- Determining (502) for the at least one or more cranking type classes the battery parameters at a current state of the battery for the at least one or more cranking type classes according to steps 200-204.
- Determining (503) the state of health of the battery from a comparison of the determined battery parameters IV, MCV, LVV in the initial state and the parameters IV, MCV, LVV in the current state by applying a normalized field method on the normalized battery parameters in the determined cranking type class, wherein the normalized battery parameters are based on the battery parameters MCV, LVV in the current state and the battery parameters MCV, LVV in the initial state.

$$normalized\ battery\ parameter = \frac{battery\ parameter\ determined\ in\ current\ state}{battery\ parameter\ in\ the\ initial\ state}$$

-Determining (504) the state of health of the battery according to the inequality

$$normalized\ LVV\ x\ normilized\ MCV < C_1 \quad (2).$$

Wherein C_1 is a constant that can be experimentally determined and its value can be for example 0.8.

The state of health of the battery is set to poor when the inequality is true. In this application an indication of the state of health as poor indicates a high change of battery failure. When the inequality is false the state of health of the battery is set to healthy. In this application an indication of the state of health as healthy indicates a new or freshly installed battery. The battery parameters of the initial state can be obtained from the local memory 13 or the database server 18.

In a next step (208) of the method the device can output the determined state of health

Fig 6 shows a graphical representation of a 2D-parameter field of the normalized LVV and the normalized MCV. Fig. 6 shows a separation line 601 indicating the separation between a healthy state and a poor state of the battery. The area including a point 602 above and right of the separation line indicates the healthy state. The area including a point 603 below and left of the separation line indicates the poor state.

Fig. 7 shows a flow diagram of a second embodiment of the method for determining a state of health from the battery parameters. According to this embodiment the step of determining the state of health of the battery in a cranking type class comprises the substeps:

-Determining (701) a moving window average of the historical battery parameter LVV and MCV for a current state based on historical battery parameter LVV and MCV corresponding to historic states or previous cranks stored in the local memory 13, or that can be retrieved via the Internet 17 from the data base server 18.

In an embodiment, the moving window average can be based on 30 stored historic states by a moving window of a width spanning 20 states, in the cranking type class from a first historic state N= -30 to a second historic state N= -10 before the current state in a the cranking type class according to formula

$$average\ battery\ parameter = \frac{1}{W} \sum_{t=T-30}^{t=T-30+W} battery\ parameter\ (t)$$

Wherein t represents a sample number t, T represents a current state and W represents the width of the window.

-Determining (702) a scaled battery parameter based on the battery parameter determined at the current state and the determined moving window average of the historical battery parameter in the cranking type class.

$$scaled\ battery\ parameter = \frac{battery\ parameter\ determined\ in\ current\ state}{avarage\ battery\ parameter}$$

Determining (703) the state of health of the battery from the scaled LVV and the scaled MCV according to the inequalities

$$scaled\ LVV\ < C_2\ .AND.\ scaled\ MCV\ < C_3$$

Wherein C_2 and C_3 respectively represents a constant that can be experimentally determined and can be for example 0.75 for both constants C_2 and C_3.

The state of health of the battery is poor when both inequalities are true.

Fig. 8 shows a graphical representation of a 2D-parameter field for the unscaled MCV and the unscaled LVV. Fig. 8 shows an ellipsoid 801 indicating an area of a healthy state of the battery. Combined values of the MCV and the LVV in the lower left corner of the field, for example a point 803 correspond to a poor state of health of the battery. A point 802 in Fig. 8 corresponds to a still healthy state.

In step (208) the device can output the determined state of health of the battery as poor indicating a high change of battery failure.

The present invention can be described as a method and apparatus for determining a state of health of a battery in a vehicle comprising determining (201) a state of charge of the battery; determining (202) a battery temperature and a cranking temperature; obtaining (204) a cranking signal from the battery when the battery is discharged during cranking of a combustion engine of

the vehicle; determining (205) one or more cranking type classes based on the determined battery temperature and the determined cranking temperature; determining (206) battery parameters from the cranking signal; determining (207) the state of health of the battery from the battery parameters, a vehicle identifier and historical battery parameters determined in a historic state preceding the current state; and outputting (206) the state of health. In this way a reliable indication can be obtained from the state of health of the battery in the vehicle.

The present invention has been described above with reference to a number of exemplary embodiments as shown in the drawings. Modifications and alternative implementations of some parts or elements are possible, and are included in the scope of protection as defined in the appended claims.

In the foregoing description of the figures, the invention has been described with reference to specific embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the scope of the invention as summarized in the attached claims.

In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiments disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

In particular, combinations of specific features of various aspects of the invention may be made. An aspect of the invention may be further advantageously enhanced by adding a feature that was described in relation to another aspect of the invention.

It is to be understood that the invention is limited by the annexed claims and its technical equivalents only. In this document and in its claims, the verb "to comprise" and its conjugations are used in their non-limiting sense to mean that items following the word are included, without excluding items not specifically mentioned. In addition, reference to an element by the indefinite article "a" or "an" does not exclude the possibility that more than one of the element is present, unless the context clearly requires that there be one and only one of the elements. The indefinite article "a" or "an" thus usually means "at least one".

Some or all aspects of the invention may be suitable for being implemented in form of software, in particular a computer program product. The computer program product may comprise a computer program stored on a non-transitory computer-readable media. Also, the computer program may be represented by a signal, such as an optic signal or an electro-magnetic signal, carried by a transmission medium such as an optic fiber cable or the air. The computer program may partly or entirely have the form of source code, object code, or pseudo code, suitable for being executed by a computer system. For example, the code may be executable by one or more processors.

CONCLUSIES

1. Werkwijze voor het bepalen van een gezondheidstoestand van een accu in een voertuig omvattende de stappen:
   a) Het bepalen (201) van een ladingstoestand van de accu;
   b) Het bepalen (202) van een accutemperatuur;
   c) Het bepalen (203) van een opstarttemperatuur;
   d) Het verkrijgen (204) van een opstartsignaal van de accu, wanneer de accu ontladen wordt door het opstarten van een verbrandingsmotor van het voertuig;
   e) Het bepalen (205) van een of meerdere opstarttype-klassen op basis van de bepaalde accutemperatuur en de bepaalde opstarttemperatuur;
   f) Het bepalen (206) van accuparameters uit het opstartsignaal overeenkomstig de bepaalde een of meerdere opstarttype-klassen;
   g) Het bepalen (207) van de gezondheidstoestand van de accu voor ten minste één of meerdere opstarttype-klassen, uit de parameters die bepaald zijn volgens opstarttype-klasse in een huidige toestand; een voertuigidentificatie en historische accuparameters overeenkomstig de één of meerdere opstarttype-klassen die bepaald zijn in een historische toestand voorafgaande aan de huidige toestand; en
   h) Het weergeven (208) van de gezondheidstoestand.

2. De werkwijze volgens conclusie 1, waarbij de historische toestand overeenkomt met een begintoestand van de accu.

3. De werkwijze volgens conclusie 2, waarbij het bepalen van de gezondheidstoestand omvat het uitvoeren van een genormaliseerd veld-werkwijze op de accuparameters in de begintoestand en de huidige toestand in de opstarttype-klasse, waarbij een gebied dat een slechte toestand van de accu is gebaseerd op twee genormaliseerde accuparameters.

4. De werkwijze volgens conclusie 2 of 3, waarbij het bepalen van de accuparameters voor de ene of meerdere opstarttype-klassen in de begintoestand omvat:

    a) Het bepalen van de accuparameters na elke van een veelvoud van opeenvolgende opstartperioden;
    b) Het bepalen van de accuparameters op basis van een gemiddelde van de bepaalde accuparameters; en
    c) Het herhalen van de stappen a) en b) voor ieder van de ene of meerdere opstarttype-klassen.

5. De werkwijze volgens conclusie 4, waarbij de accuparameters omvatten: een initiële spanning, IV, een laagste spanningswaarde, LVV, en een gemiddelde opstartspanning, MCV.

6. De werkwijze volgens conclusie 1, waarbij het bepaalde van de gezondheidstoestand omvat:
    Het bepalen van een lopend gemiddelde van de historische accuparameters van een veelvoud van historische toestanden in de opstarttype-klasse;
    Het bepalen van een gewogen accuparameter op basis van een accuparameter in een huidige toestand en het bepaalde lopend gemiddelde van de historische accuparameter in de opstarttype-klasse; en
    Het bepalen van de gezondheidstoestand van de accu uit de gewogen accuparameters.

7. De werkwijze volgens conclusie 6, waarbij het lopend gemiddelde van de historische accuparameters wordt bepaald van een eerste historische toestand N-30 tot een tweede historisch toestand N-10 voorafgaand aan de huidige toestand N in de opstarttype-klasse.

8. De werkwijze volgens conclusie 6 of 7, waarbij de accuparameters de LVV en de MCV omvatten.

9. De werkwijze volgens conclusie 1, waarbij het bepalen van de ladingstoestand van de accu omvat:
Het bepalen, na een rustperiode van de verbrandingsmotor, een rustspanning van de accu;
Het bepalen van een referentierustspanning op basis van de rustspanning;
Het meten van de rustspanning van de accu in een huidige toestand na een werkperiode op basis van de referentierustspanning, de gemeten rustspanning en de werkperiode.

10. De werkwijze volgens conclusie 1, waarbij de accutemperatuur wordt bepaald op basis van de motorkoelvloeistoftemperatuur, een omgevingstemperatuur, een motortemperatuur, een tijdsduur van de laatste werkperiode van de verbrandingsmotor en de tijd verstreken sinds de laatste werkperiode.

11. De werkwijze volgens conclusie 1, waarbij de opstarttemperatuur wordt bepaald op basis van de motorkoelvloeistoftemperatuur, een omgevingstemperatuur, een motortemperatuur en de tijd verstreken sinds de laatste werkperiode.

12. Een inrichting voor het bepalen van een gezondheidstoestand van een accu (2) in een voertuig (1) omvattende:
- Een geheugeninrichting (13) ;
- Een invoerinrichting (12) ;
- Een uitvoerinrichting (14) omvattende een beeldweergave inrichting;
- Een communicatieinrichting (15) ingericht voor het communiceren naar een controleinrichting van het voertuig; en
- Een besturingseenheid (11) ingericht voor

a) Het bepalen van een ladingstoestand van de accu;
b) Het bepalen van een accutemperatuur;
c) Het bepalen van een opstarttemperatuur;
d) Het verkrijgen van een opstartsignaal van de accu, wanneer de accu ontladen wordt door het opstarten van een verbrandingsmotor van het voertuig;
e) Het bepalen van een of meerdere opstarttype-klassen op basis van de bepaalde accutemperatuur en de bepaalde opstarttemperatuur;

f) Het bepalen van accuparameters uit het opstartsignaal overeenkomstig de bepaalde een of meerdere opstarttype-klassen;

g) Het bepalen van de gezondheidstoestand van de accu voor ten minste één of meerdere opstarttype-klassen, uit de parameters die bepaald zijn volgens opstarttype-klasse in een huidige toestand; een voertuigidentificatie en historische accuparameters overeenkomstig de één of meerdere opstarttype-klassen die bepaald zijn in een historische toestand voorafgaande aan de huidige toestand; en

h) Het weergeven van de gezondheidstoestand via de uitvoerinrichting (12).

13. Een computerprogrammaproduct omvattende computerprogrammacode-middelen ingericht voor het uitvoeren van de stappen van elke werkwijzeconclusies 1 tot 11, wanneer het computerprogramma wordt uitgevoerd op een computer.

14. Een computer-leesbaar opslagmedium voor het doen uitvoeren op een computer van de stappen van de werkwijze volgens elke van de conclusies 1-11.

Fig. 1

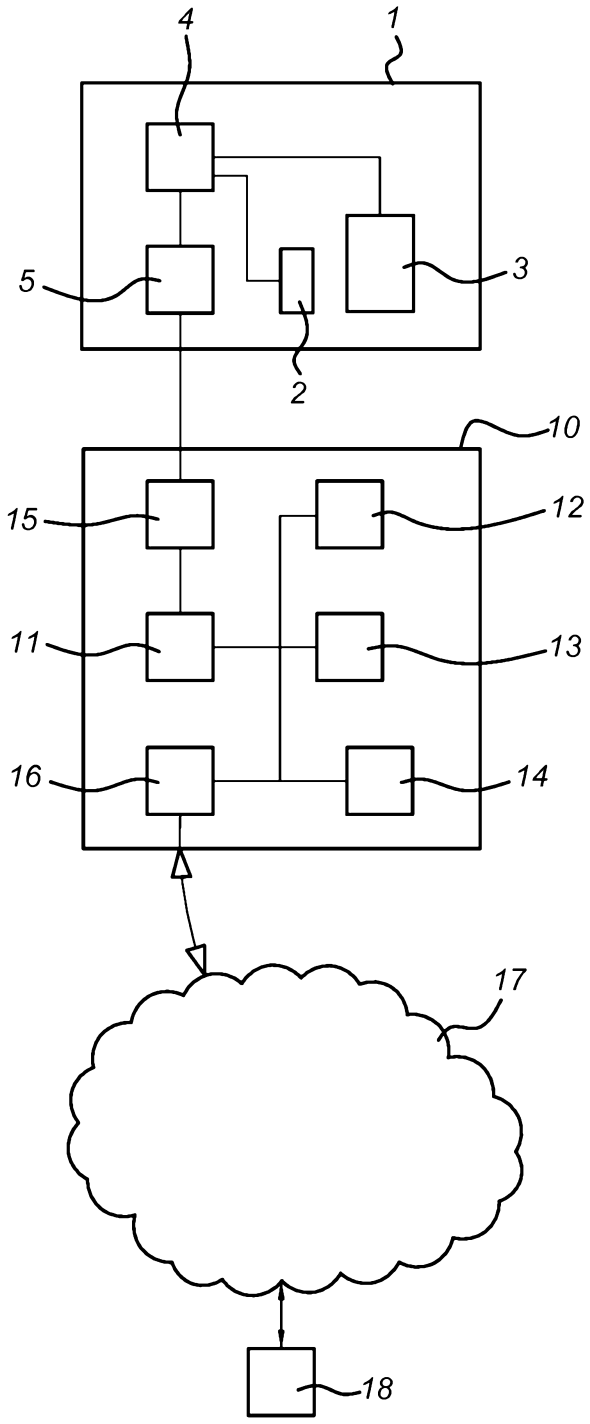

Fig. 2

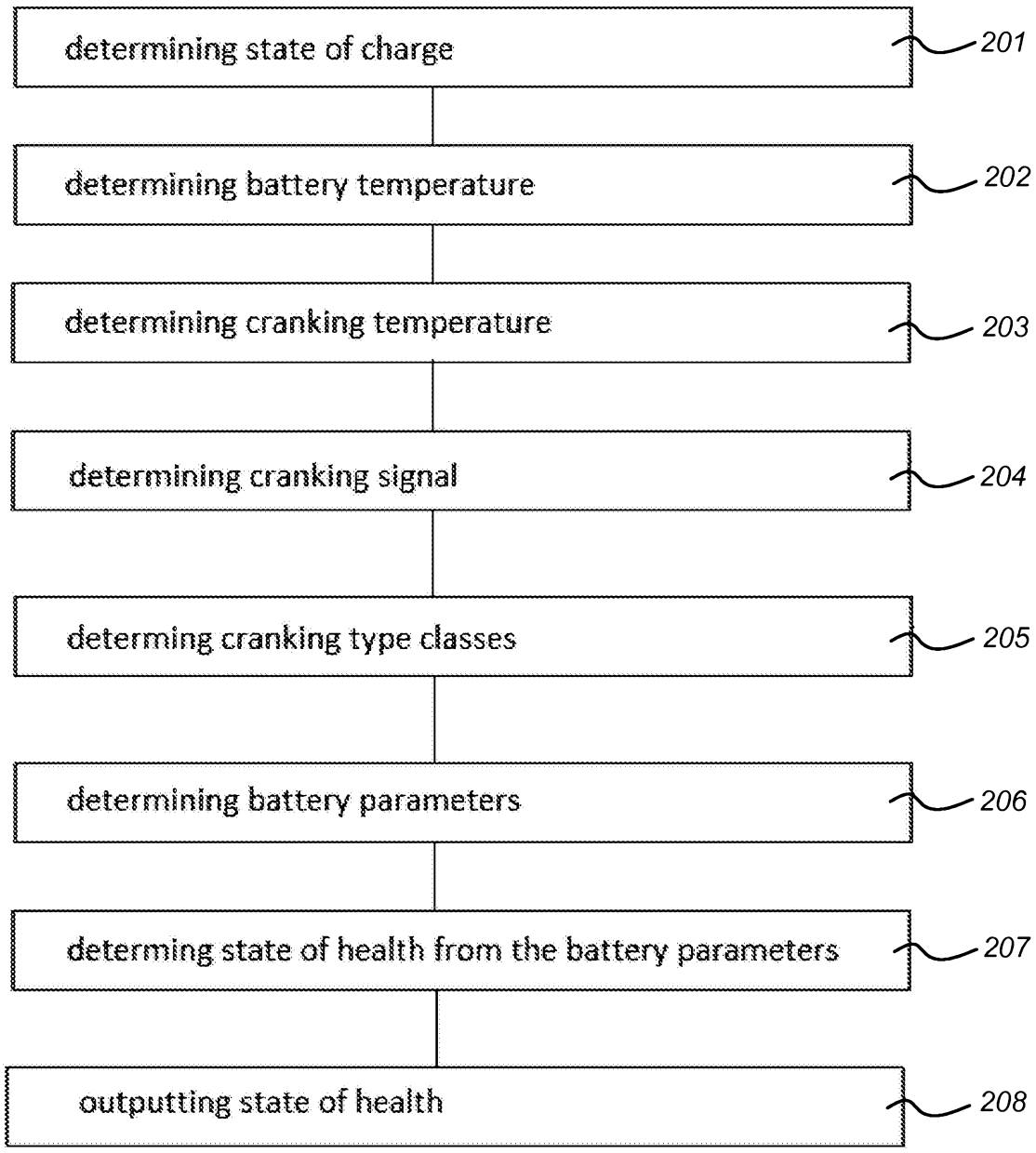
determining state of charge
201
determining battery temperature
202
determining cranking temperature
203
determining cranking signal
204
determing cranking type classes
205
determining battery parameters
206
determing state of health from the battery parameters
207
outputting state of health
208

Fig. 3

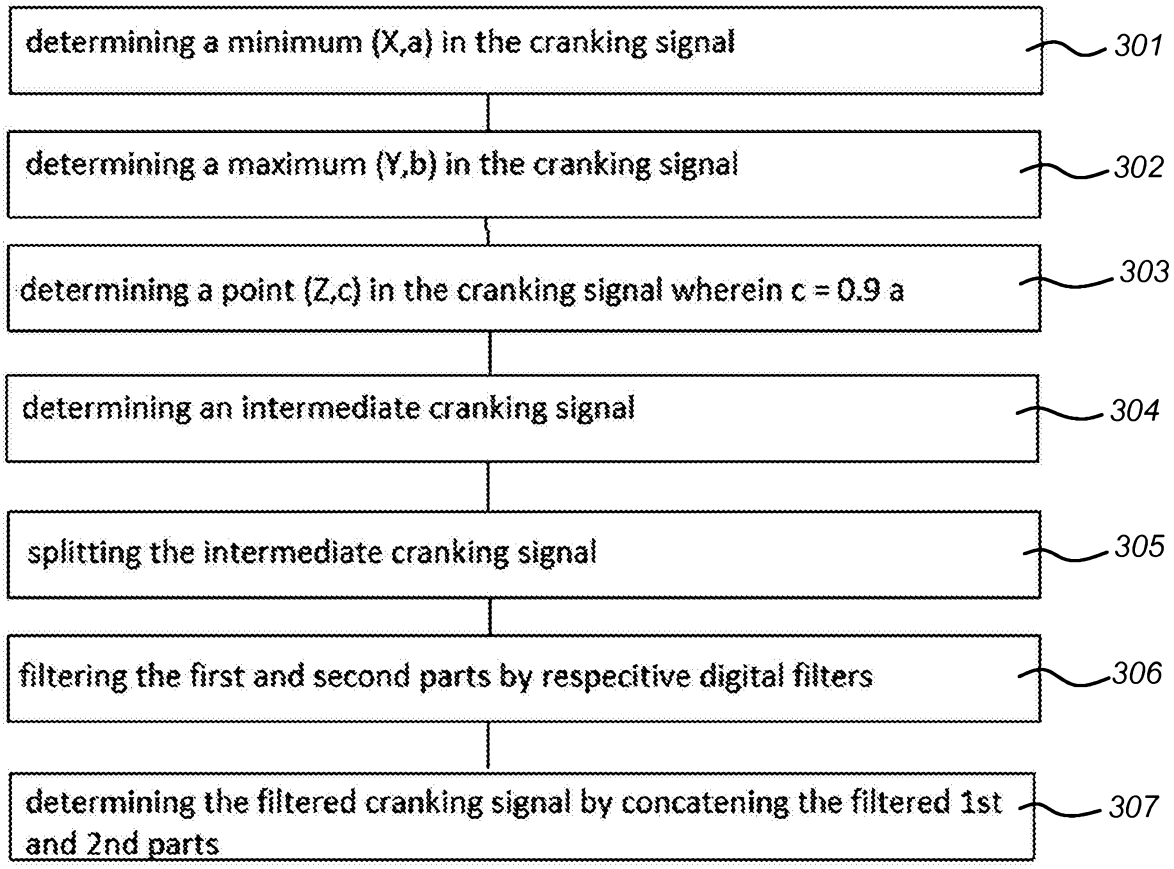
determining a minimum (X,a) in the cranking signal
301
determining a maximum (Y,b) in the cranking signal
302
determining a point (Z,c) in the cranking signal wherein c = 0.9 a
303
determining an intermediate cranking signal
304
splitting the intermediate cranking signal
305
filtering the first and second parts by respecitive digital filters
306
determining the filtered cranking signal by concatening the filtered 1st and 2nd parts
307

Fig. 4

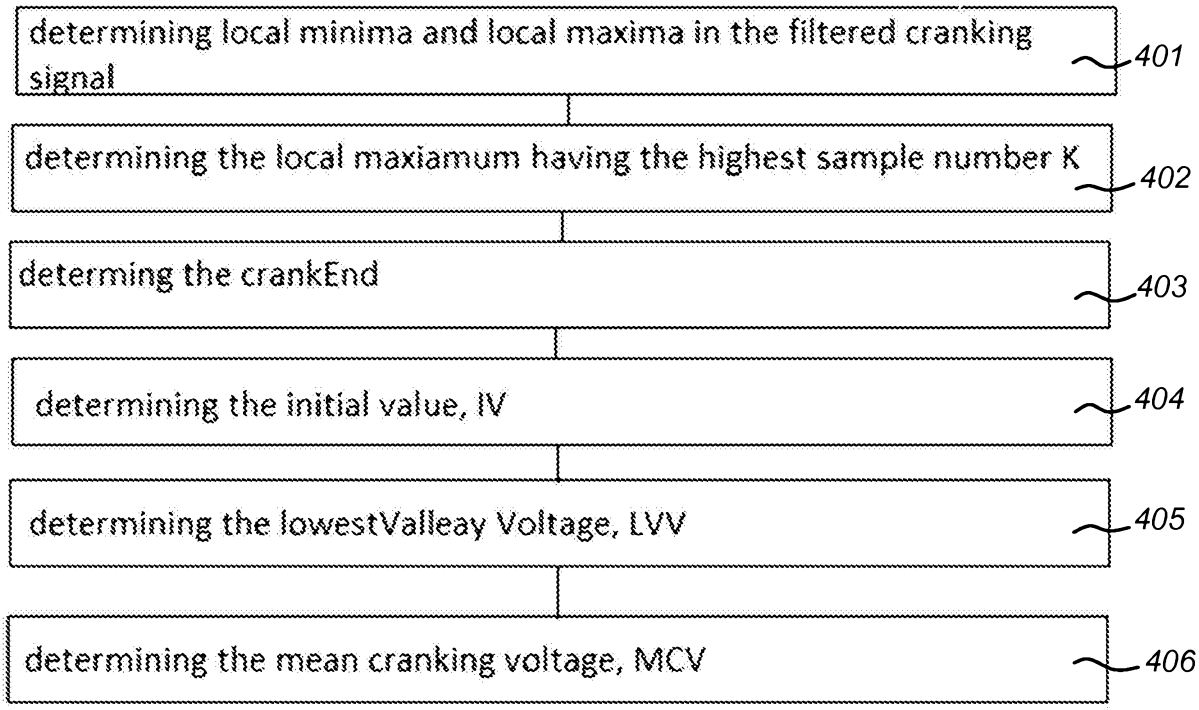
determining local minima and local maxima in the filtered cranking signal
401
determining the local maxiamum having the highest sample number K
402
determing the crankEnd
403
determining the initial value, IV
404
determining the lowestValleay Voltage, LVV
405
determining the mean cranking voltage, MCV
406

Fig. 5

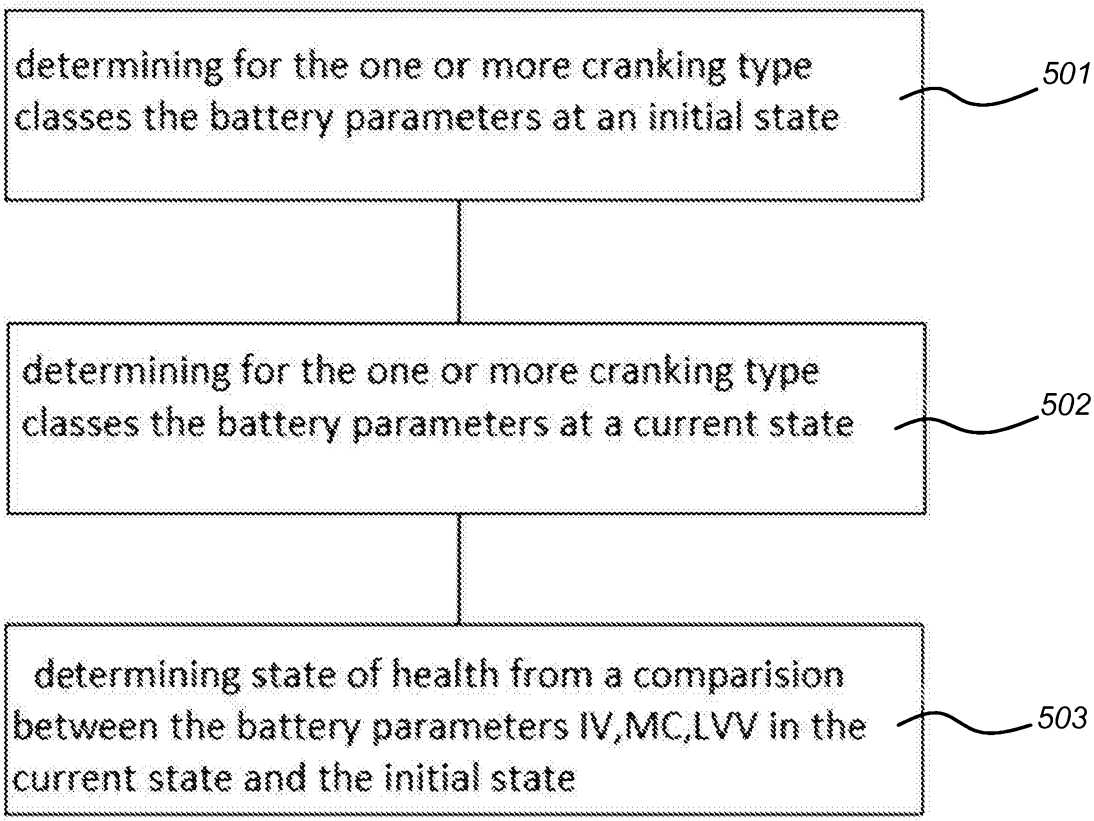
determining for the one or more cranking type classes the battery parameters at an initial state
501
determining for the one or more cranking type classes the battery parameters at a current state
502
determining state of health from a comparision between the battery parameters IV,MC,LVV in the current state and the initial state
503

Fig. 6

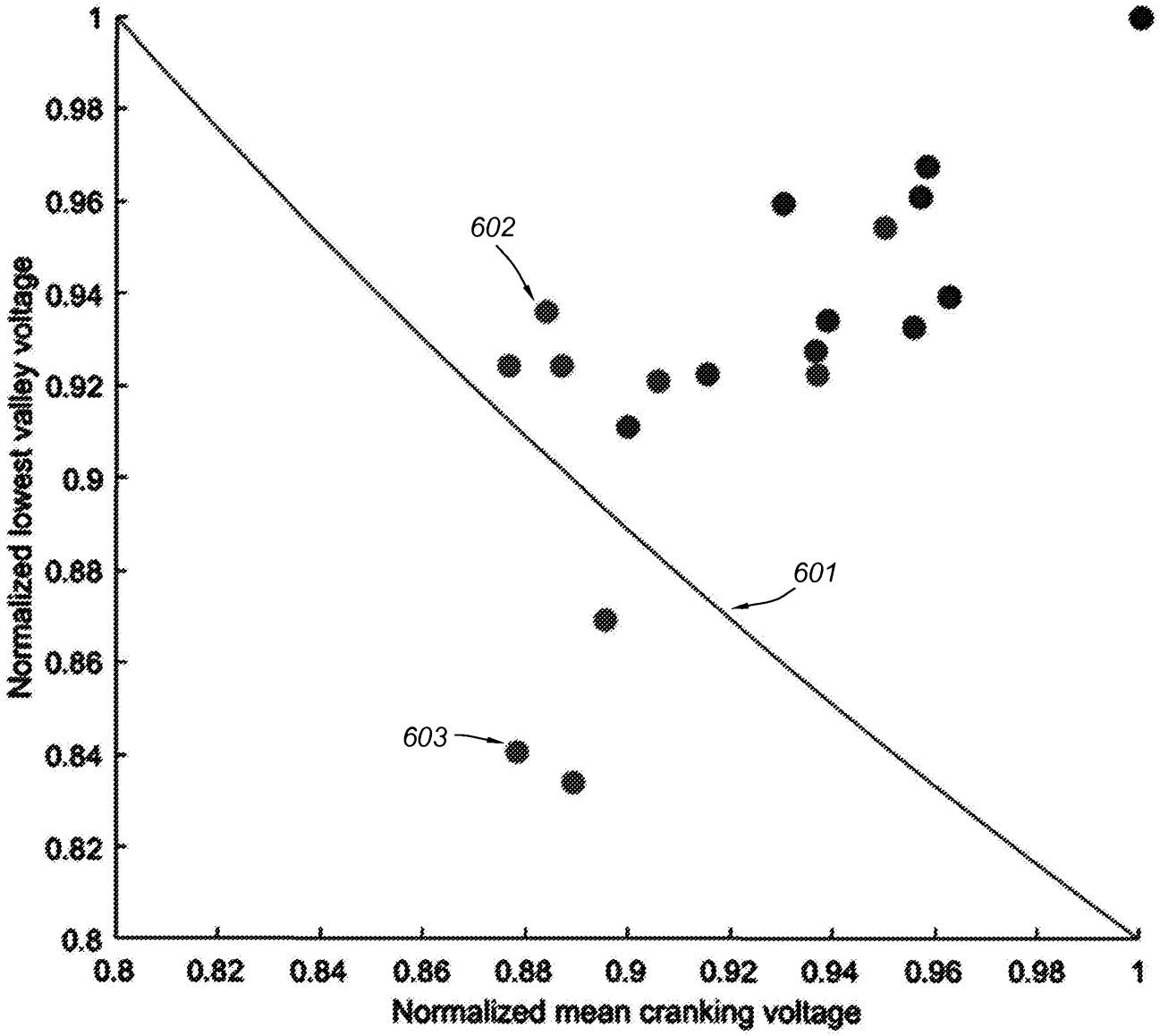
Normalized lowest valley voltage
Normalized mean cranking voltage
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0.8
0.8
0.82
0.84
0.86
0.88
0.9
0.92
0.94
0.96
0.98
1
602
601
603

Fig. 7

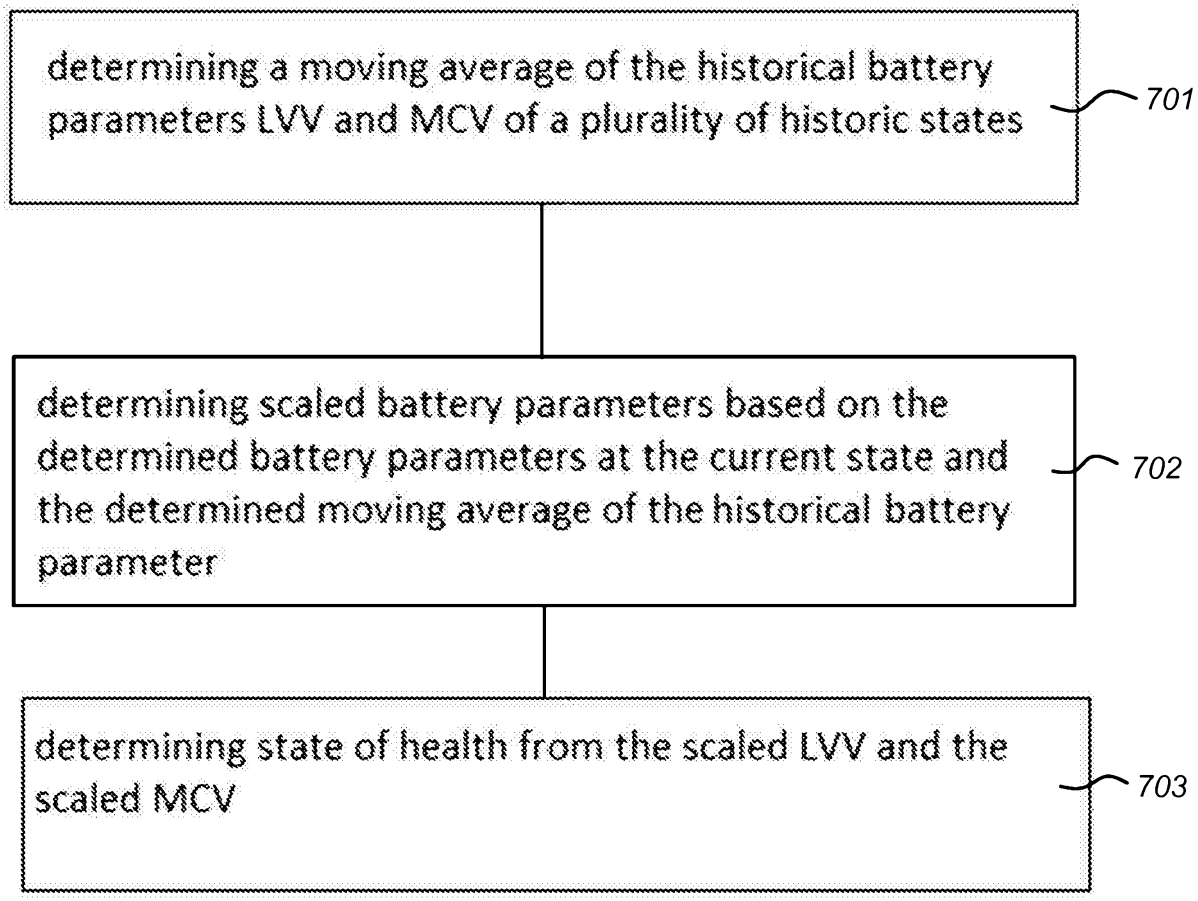
determining a moving average of the historical battery parameters LVV and MCV of a plurality of historic states
701
determining scaled battery parameters based on the determined battery parameters at the current state and the determined moving average of the historical battery parameter
702
determining state of health from the scaled LVV and the scaled MCV
703

Fig. 8

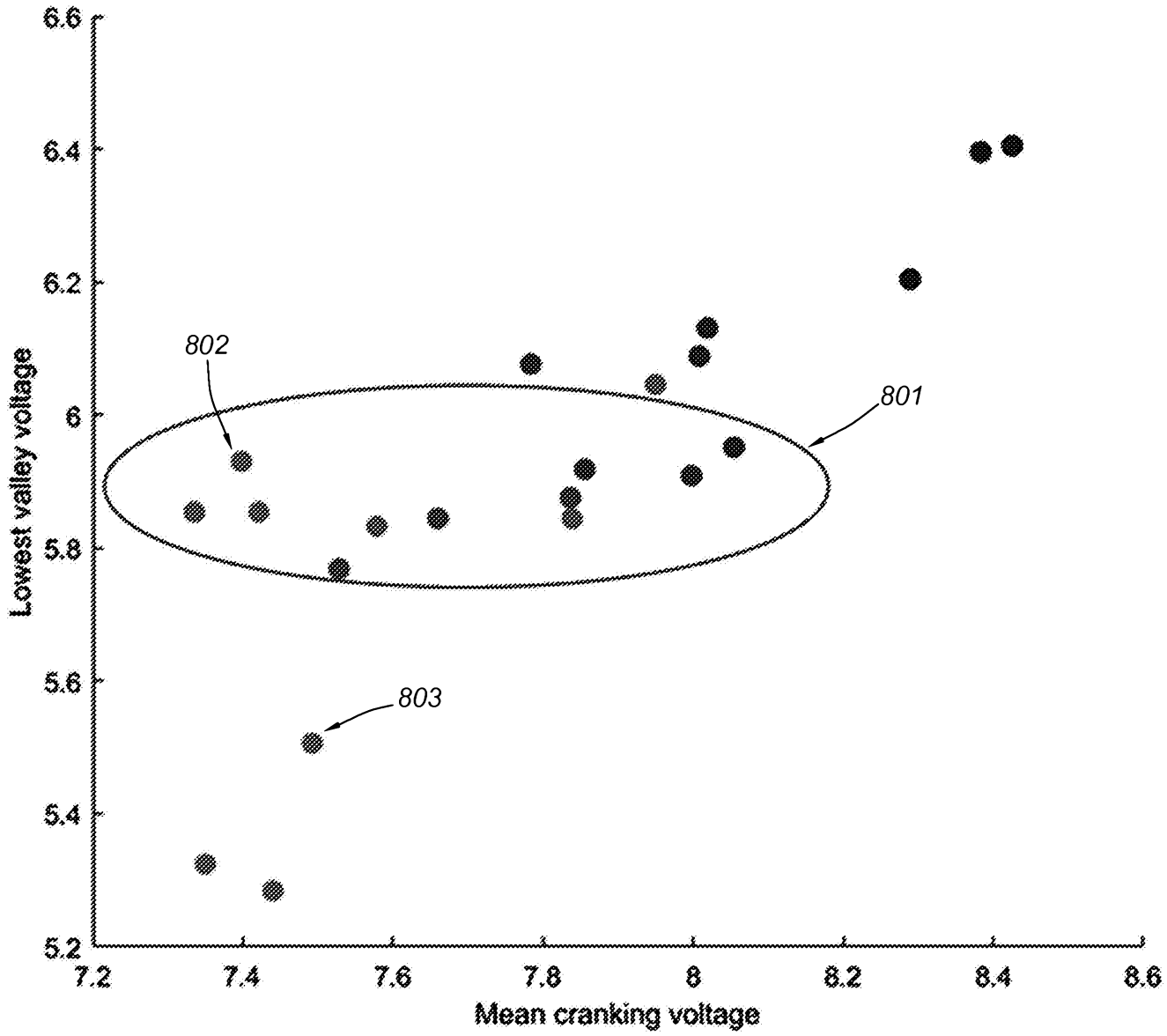
6.6
6.4
6.2
6
5.8
5.6
5.4
5.2
Lowest valley voltage
802
801
803
7.2
7.4
7.6
7.8
8
8.2
8.4
8.6
Mean cranking voltage

Fig. 9

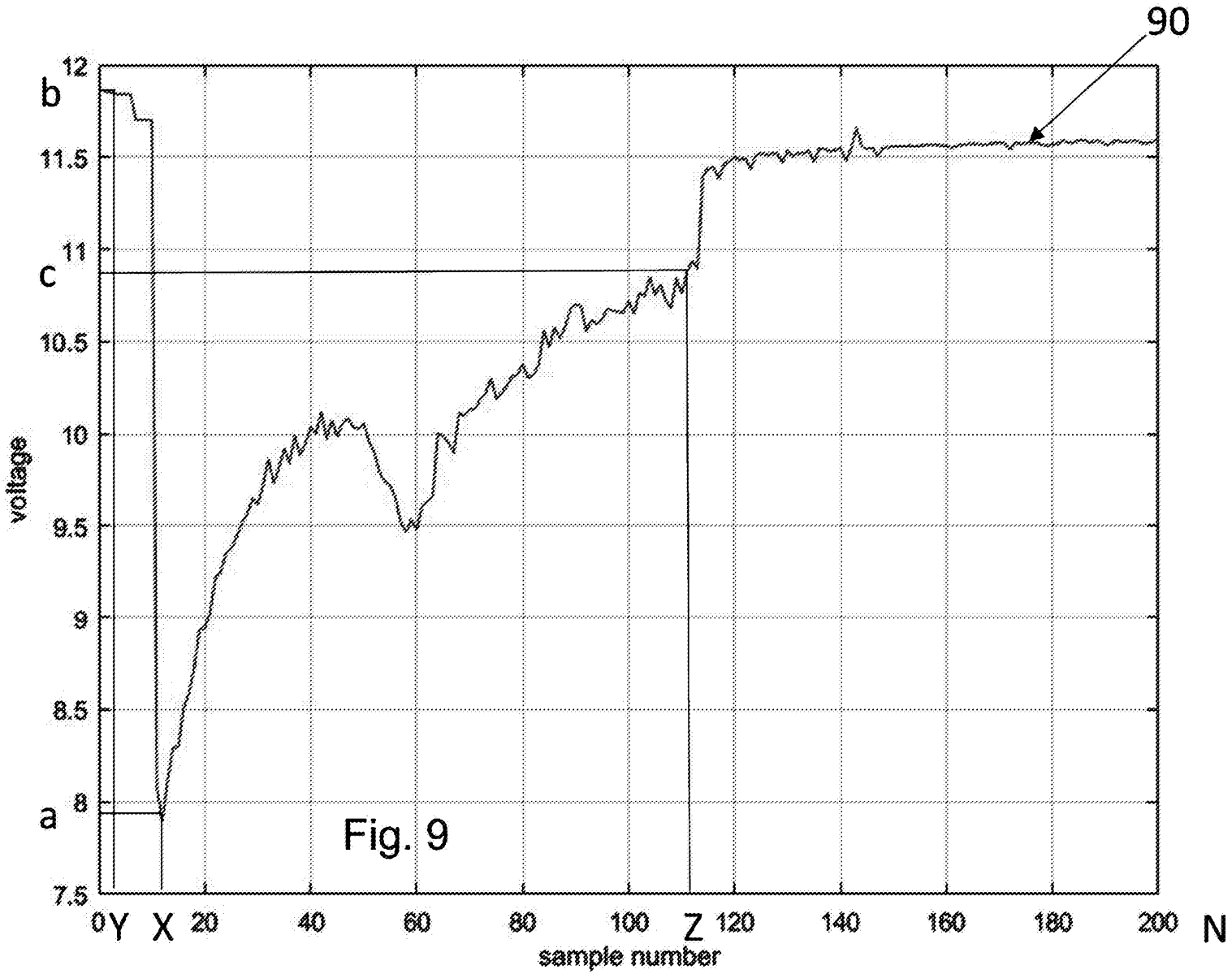
90
b
c
a
12
11.5
11
10.5
10
9.5
9
8.5
8
7.5
voltage
0
Y
X
20
40
60
80
100
Z
120
140
160
180
200
N
sample number

Fig. 9

Abstract

The invention relates to a method and apparatus for determining a state of health of a battery in a vehicle comprising determining (201) a state of charge of the battery; determining (202) a battery temperature and a cranking temperature; obtaining (204) a cranking signal from the battery when the battery is discharged during cranking of a combustion engine of the vehicle; determining (205) one or more cranking type classes based on the determined battery temperature and the determined cranking temperature; determining (206) battery parameters from the cranking signal; determining (207) the state of health of the battery from the battery parameters, a vehicle identifier and historical battery parameters determined in a historic state preceding the current state; and outputting (206) the state of health. In this way a reliable indication can be obtained from the state of health of the battery in the vehicle.

Fig. 1

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE
	P6070119NL
Nederlands aanvraag nr. **2019831**	Indieningsdatum **30-10-2017**
	Ingeroepen voorrangsdatum
Aanvrager (Naam) **ANWB B.V.**	
Datum van het verzoek voor een onderzoek van internationaal type **25-11-2017**	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr. **SN70092**

I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)

Volgens de internationale classificatie (IPC)

G01R31/36;B60L11/18

II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimumdocumentatie

Classificatiesysteem	Classificatiesymbolen
IPC	**G01R;B60L**

Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

III.	☐	**GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES**	(opmerkingen op aanvullingsblad)
IV.	☐	**GEBREK AAN EENHEID VAN UITVINDING**	(opmerkingen op aanvullingsblad)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2019831

A. CLASSIFICATIE VAN HET ONDERWERP
INV. G01R31/36
ADD. B60L11/18

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC

B. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimum documentatie (classificatie gevolgd door classificatiesymbolen)
G01R B60L

Onderzochte andere documentatie dan de minimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)
EPO-Internal, WPI Data

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
X	US 6 118 252 A (RICHTER GEROLF [DE]) 12 september 2000 (2000-09-12) * kolom 2, regel 31 - kolom 3, regel 47; figuur 2 * -----	1-14
X A	US 2015/361941 A1 (DU XINYU [US] ET AL) 17 december 2015 (2015-12-17) * alineas [0011], [0012], [0017], [0019], [0027] - [0030], [0041] - alinea [0044]; figuur 2 * -----	1,12-14 10,11
X	WO 2009/158224 A2 (GM GLOBAL TECH OPERATIONS INC [US]) 30 december 2009 (2009-12-30) * alineas [0004], [0005], [0012] - alinea [0019]; figuren 1,2 * ----- -/--	1,12-14

[X] Verdere documenten worden vermeld in het vervolg van vak C

[X] Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

° Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvrage vermeld

"E" eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid	Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type
5 juli 2018	

Naam en adres van de instantie	De bevoegde ambtenaar
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Hof, Klaus-Dieter

1

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2019831

C. (Vervolg) VAN BELANG GEACHTE DOCUMENTEN

Categorie *	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A	WO 2009/158225 A2 (GM GLOBAL TECH OPERATIONS INC [US]) 30 december 2009 (2009-12-30) * alineas [0001], [0015] - alinea [0028]; figuren 1-4,6 *	1-14
A	WO 2014/098837 A1 (SCHNEIDER ELECTRIC USA INC [US]) 26 juni 2014 (2014-06-26) * samenvatting; figuren 2-6 *	1-14
A	US 6 472 875 B1 (MEYER HENRY-LOUIS [FR]) 29 oktober 2002 (2002-10-29) * kolom 3, regel 1 - kolom 4, regel 32; figuren 1-6 *	1-14
A	US 6 727 708 B1 (DOUGHERTY THOMAS J [US] ET AL) 27 april 2004 (2004-04-27) * kolom 6, regel 49 - kolom 10, regel 51; figuur 5 *	1-14

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar de stand van de techniek: NL 2019831

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)		Datum van publicatie
US 6118252	A 12-09-2000	BR	9804628 A	03-11-1999
		DE	19750309 A1	20-05-1999
		EP	0916959 A2	19-05-1999
		ES	2242991 T3	16-11-2005
		US	6118252 A	12-09-2000
US 2015361941	A1 17-12-2015	GEEN		
WO 2009158224	A2 30-12-2009	CN	102077408 A	25-05-2011
		DE	112009001552 T5	12-05-2011
		US	2009322340 A1	31-12-2009
		WO	2009158224 A2	30-12-2009
WO 2009158225	A2 30-12-2009	US	2009326841 A1	31-12-2009
		WO	2009158225 A2	30-12-2009
WO 2014098837	A1 26-06-2014	EP	2936187 A1	28-10-2015
		US	2016003919 A1	07-01-2016
		WO	2014098837 A1	26-06-2014
US 6472875	B1 29-10-2002	DE	69817384 D1	25-09-2003
		DE	69817384 T2	24-06-2004
		EP	1019744 A1	19-07-2000
		ES	2205561 T3	01-05-2004
		FR	2769095 A1	02-04-1999
		US	6472875 B1	29-10-2002
		WO	9917128 A1	08-04-1999
US 6727708	B1 27-04-2004	US	6727708 B1	27-04-2004
		US	2004189257 A1	30-09-2004

WRITTEN OPINION

File No.	Filing date *(day/month/year)*	Priority date *(day/month/year)*	Application No.
SN70092	30.10.2017		NL2019831

International Patent Classification (IPC)
INV. G01R31/36 ADD. B60L11/18

Applicant
ANWB B.V.

This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the application
- ☒ Box No. VIII Certain observations on the application

	Examiner
	Hof, Klaus-Dieter

Application number

WRITTEN OPINION

NL2019831

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the application as filed.

   ☐ filed together with the application in electronic form.

   ☐ furnished subsequently for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes:	Claims	3, 6-14
	No:	Claims	1, 2, 4, 5
Inventive step	Yes:	Claims	
	No:	Claims	1-14
Industrial applicability	Yes:	Claims	1-14
	No:	Claims	

2. Citations and explanations

see separate sheet

WRITTEN OPINION

Box No. VII Certain defects in the application

see separate sheet

Box No. VIII Certain observations on the application

see separate sheet

1 **Re Item V**

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1.1 Reference is made to the following documents:

D1 US 6 118 252 A (RICHTER GEROLF [DE]) 12 september 2000 (2000-09-12)

D2 US 2015/361941 A1 (DU XINYU [US] ET AL) 17 december 2015 (2015-12-17)

D3 WO 2009/158224 A2 (GM GLOBAL TECH OPERATIONS INC [US]) 30 december 2009 (2009-12-30)

D4 WO 2009/158225 A2 (GM GLOBAL TECH OPERATIONS INC [US]) 30 december 2009 (2009-12-30)

D5 WO 2014/098837 A1 (SCHNEIDER ELECTRIC USA INC [US]) 26 juni 2014 (2014-06-26)

D6 US 6 472 875 B1 (MEYER HENRY-LOUIS [FR]) 29 oktober 2002 (2002-10-29)

D7 US 6 727 708 B1 (DOUGHERTY THOMAS J [US] ET AL) 27 april 2004 (2004-04-27)

1.2 The present application does not meet the criteria of patentability, because the subject-matter of claim 1 is not new:

1.2.1 D1 discloses (references in parentheses are relating to said document):

Werkwijze voor het bepalen van een gezondheidstoestand van een accu in een voertuig (col.2 l.32; col.3 l.37 application defines SOH) omvattende de stappen:
a) Het bepalen van een ladingstoestand van de accu (col.3 l.29-33, OCV is measured and thus SOC determined) ;
b) Het bepalen van een accutemperatuur (col.3 l.13-14);
c) Het bepalen van een opstarttemperatuur (col.3 l.14) ;
d) Het verkrijgen van een opstartsignaal van de accu, wanneer de accu ontladen wordt door het opstarten van een verbrandingsmotor van het voertuig (col.3 l.12);
e) Het bepalen van een of meerdere opstarttype-klassen op basis van de

bepaalde accutemperatuur en de bepaalde opstarttemperatuur (Fig.2, look-up table defining 8x8=64 cranking type classes depending on starter temperature T_M and battery temperature T_B);
f) Het bepalen van accuparameters uit het opstartsignaal overeenkomstig de bepaalde een of meerdere opstarttype-klassen (Fig.2; DeltaU_B for the respective temperatures);
g) Het bepalen van de gezondheidstoestand van de accu voor ten minste één of meerdere opstarttype-klassen, uit de parameters die bepaald zijn volgens opstarttype-klasse in een huidige toestand; een voertuigidentificatie en historische accuparameters overeenkomstig de één of meerdere opstarttype-klassen die bepaald zijn in een historische toestand voorafgaande aan de huidige toestand (col.3 l.18-22, col.3 l.39-46); en
h) Het weergeven van de gezondheidstoestand (col.3 l.24 or claim 1 step (e), indication or alarming is seen as an output of an unsufficient health state).

1.2.2 Furthermore, it is considered that likewise the disclosure of documents D2 or D3 taken on its own would be relevant for considering patentability of the claimed subject-matter (see pertinent passages cited in the search report).

1.3 Corresponding claim 12 defining a corresponding device and claims 13 and 14 defining a corresponding computer program product respectively a corresponding medium and the claimed subject-matter in theses claims does therefore lack inventive step as these are considered mere customary implementations of the non-novel process disclosed in D1 (see point 1.2.1 above).

1.4 Dependent claims 2-11 do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of novelty and/or inventive step, because either the additional features are already known from one of D1-D7 (see respective pertinent passages cited in the search report) or the claimed subject-matter appears to define merely a slight constructional change of the known SOH determination methods which appears to come within the scope of the customary practice followed by persons skilled in the art, especially as the advantages thus achieved can readily be foreseen. In particular,

1.4.1 D1 discloses "de historische toestand overeenkomt met een begintoestand van de accu" (col.3 l.19 "new phase"){claim 2}

1.4.2 it is known to use such normalized field methods in SOH battery classfication problems (see e.g. [0042] of D2 or [0028] of D4){claim 3}

1.4.3 D1 further discloses to repeatedly determining the parameters in the initial state (col.3 l13.16) and to determine an average (D1 claim 1 step (c)"mean value of voltage surges") {claim 4}

1.4.4 D1 further discloses to determine "een initiële spanning"("the rest voltage", col.3 l.32),"een laagste spanningswaarde" (col.3 l.20 "voltage surge DeltaU_B") and "een gemiddelde opstartspanning" (D1 claim 1 step (c)"mean value of voltage surges") {claim 5}

1.4.5 The use of moving averaged values instead of initial values is considered to represent a standard practice known to the person skilled in the art and which does not provide any unexpected, emerging technical effects (claims 6-8)

1.4.6 D1 discloses to determine the SOC via the OCV (col.3 l.29-33), implementations thereof being considered as customary {claim 9}, as is determination of battery temperature and starter temperature (cf. also D2 [0027]){claims 10 and 11}

2 **Re Item VII**

Certain defects in the application

2.1 Independent claims 1,12,13 and 14 are not in the two-part form, with those features known in combination from the prior art being placed in the preamble and the remaining features being included in the characterising part.

2.2 The relevant background art disclosed in documents D1-D7 is not mentioned in the description, nor is this document identified therein.

3 **Re Item VIII**

Certain observations on the application

3.1 Claims 1 and 7 are not clear:

3.1.1 Claim 1 comprises an "opstarttemperatuur" and it appears unclear, whether this relates to the temperature **of the starter** or to the temperature (of what?) **at start.**

3.1.2 Claim 7 refers to claim 6 or 7 only but comprises battery parameters "LVV" and "MCV" which are only defined in claim 5, thus leaving these parameters without proper defining antecedent.