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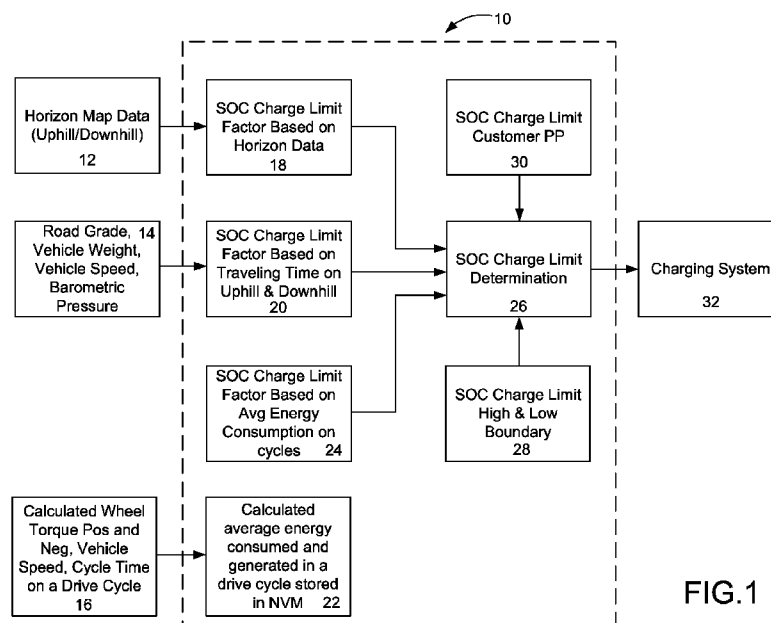


FIG.1

(57) Abstract: An intelligent charge limit for high voltage battery charging provides increased e-motor regeneration and reduced application of the foundation brake system of an electric vehicle. A plurality of data factors are used to calculate a maximum charge percentage. The maximum charge percentage is used to ensure there is enough charging capacity in a battery to store electrical current generated by an e-motor during downhill travel. The intelligent charge limit also provides an operator of the electric vehicle, the option of changing the charge limit to ensure that the battery receives the maximum electrical current generated by an e-motor, during downhill travel. The operator may also double plug a charging gun to eliminate a state of charge routine from considering offsetting the operator charging percentage by the plurality of data factors.

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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

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

INTELLIGENT CHARGE LIMIT FOR HIGH VOLTAGE BATTERIES

REFERENCE TO RELATED APPLICATIONS

This patent application claims benefit of United States Patent Application Number 17/858,742, filed on July 6, 2022. That patent application is incorporated herein in its entirety by this reference.

FIELD OF THE INVENTION

The present invention pertains to limiting the charge from an external charging source to a high voltage battery of a vehicle.

RELATED ART

Charging capacity of high voltage batteries is limited to about 90% - 98% of a State of Charge (SOC), which is a calibration set by an OEM. When the state of charge of the battery is full, regeneration from an e-motor cannot function, because the electrical current generated by the e-motor cannot be stored in the high voltage battery, unless there is a mechanism on the vehicle to absorb it. Consequently, electrical current generated by the e-motor during downhill travel is wasted, because it cannot be stored in the battery. Thus, regeneration brake force from the e-motor cannot be used to slow down the vehicle. Further, if there is no heat dissipation resistor hardware component to waste energy at the e-motor, the electrical current cannot be stored in the battery and regeneration braking cannot occur. In this case, the foundation brakes can only be used to slow down the vehicle. E-motor regeneration normally decreases application of the foundation brakes.

Accordingly, there is a clearly felt need in the art for intelligently limiting charge of a high voltage battery, which allows the charge limit to be modified according to the terrain traveled by a vehicle; provide increased e-motor regeneration and reduce the number of

applications of a foundation brake system; reduced risk of regeneration braking cut-out, reduced time and operating expenses for charging from an external source and a vehicle operator to change a maximum state of charge percentage.

SUMMARY

The present disclosure is an intelligent charge limit for high voltage battery charging, which provides increased e-motor regeneration and reduced application of the foundation brake system, reduced risk of regeneration braking cut-out and reduced time and operating expenses for charging from an external source. The intelligent charge limit also provides an operator of an electric vehicle powered by high voltage batteries and/or fuel cell systems the option of changing a charge limit to ensure that the battery receives the maximum amount of electrical current generated by an e-motor, during downhill travel. Less reliance on the foundation brake will prevent overheating of the foundation brake system during a long downhill road segment in the summertime. The intelligent charge limit will also prevent regeneration cutout, when the battery has no more room to receive electrical current from the e-motor during downhill travel. Less time will be spent at the charging station as a result of decreasing the maximum charge limit of the battery. The intelligent charge limit is applied to heavy and medium duty vehicles including school busses. The intelligent charge limit will not allow a charger gun to charge the battery greater than a preset maximum charge percentage as determined by a charge routine and/or an operator of the vehicle for anticipated downhill segments in a travel route. The intelligent charge limit includes the benefits of reduced risk of regeneration cutout; less time spent at a charging station; maximum use of regenerative braking; fewer applications of the foundation brakes and reduced operating expenses for charging the battery; and allowing an operator to change the maximum charge percentage.

DESCRIPTION OF THE DRAWINGS

Figure 1 is a flow chart of intelligent charge limit for a high voltage battery in accordance with the present invention.

Figure 2 is an illustration of a vehicle about to travel a route with multiple downhill segments.

Figure 3 is an illustration of upper and lower charge boundaries of an intelligent charge limit for a high voltage battery in accordance with the present invention.

DETAILED DESCRIPTION

With reference now to the drawings, and particularly to figure 1, there is shown an intelligent charge limit flow chart 10. An intelligent charge limit algorithm 5 receives data inputs from a horizon map 12; a road grade sensor 14; and wheel torque and vehicle speed 16. Horizon map data from the horizon map 12 will show if there is a future downhill road segment. Based on the data inputs from the horizon map 12, the road grade sensor 14 and the wheel torque and vehicle speed 16, the intelligent charge limit algorithm 5 will determine if and the amount that the maximum charge limit should be reduced and thus adjust the maximum charge limit accordingly. The road grade sensor 14 provides a slope of the terrain either positive or negative. With reference to figure 2, accumulated travelling distance based on information from the road grade sensor 14 will indicate whether the vehicle 100 is traveling on a relatively flat road surface or not. A flat travel route will be determined by monitoring information from the road grade sensor 14, vehicle speed, and using an up/down counter. The flat travel route will not result in any adjustment to the state of charge limit.

Wheel torque and vehicle speed 16 are used to calculate an average percentage of energy consumption and generation with regeneration for a duty cycle based on multiple trips for highway and city cycles, utilizing a list of parameters stored in ECU, NVM or cloud to calculate

the state of charge limit offset. A map state of charge limit factor 18 is calculated based on horizon data provided by the horizon map 12. A grade state of charge limit factor 20 is calculated based on data provided by the road grade sensor 14. A value of calculated average energy consumed and generated 22 is generated from the wheel torque and vehicle speed 16. A wheel state of charge limit factor 24 is calculated based on average energy consumed and generated 22. With reference to figure 3, a state of charge routine 26 receives input from the map state of charge limit factor 18, the grade state of charge limit factor 20 and the wheel state of charge limit factor 24.

The map state of charge limit factor 18, the grade state of charge limit factor 20 and the wheel state of charge limit factor 24 are all dynamic offset factors, which will change depending upon the travel route 102. Further, the map state of charge limit factor 18, the grade state of charge limit factor 20 and the wheel state of charge limit factor 24 are all dependent upon the loading of the vehicle. An e-motor of a lightly loaded vehicle will produce less electrical current output during downhill travel than a more heavily loaded vehicle. Consequently, a smaller charge limit reduction would be appropriate. With reference to figure 3, the state of charge routine 26 is also provided with preset upper and lower state of charge limit boundaries 28. It is preferable to have a maximum high limit state of charge percentage and a minimum low limit state of charge percentage. The maximum charge limit provides charging capacity in the high voltage battery to receive electrical charge from regenerative braking. The minimum charge limit prevents the customer from setting the state of charge limit percentage to low with a customer programable parameter 30.

With reference to figure 3, the state of charge limit routine 26 receives input from the vehicle operator through customer programable parameter 30. The vehicle operator is allowed to introduce a maximum charge limit based on their fixed vehicle operation route. The maximum charge limit is preferably entered through a customer programable parameter or

some type of human machine interface (HMI), which could be password protected. A fleet manager can determine which drivers get access to the password. The minimum lower limit is protected by the OEM to prevent a setting, which is too low. If the customer operates on a relatively flat travel route, such as Illinois or Indiana, the maximum charge limit can be programmed closer to the maximum charge boundary, such as 95%. However, if a customer operates in a mountain terrain area, the state of charge limit percentage can be programmed to a lower value, such as 80%, which will leave some room to charge the high voltage battery with regenerative braking while travelling downhill. The 80% value will also ensure most of the braking will derive from regeneration and not the foundation brake system. In addition, time spent at the charging station will be less, since the customer does not need to wait until the high voltage battery is charged to a percentage value in the high 90s. Approaching the maximum charge limit of the high voltage battery takes longer than a lower percentage limit. Thus, charging the high voltage battery to a lower limit will result in the customer spending less time at the charging station 104.

In order to provide flexibility and convenience to customers, the customer programmable parameter 30 will allow customers to override the dynamic offset factors during charging at the charging station 104. Once charging is successfully completed to the customer programmable parameter 30, operator needs to unplug a charger gun and plug it back to override the dynamic offset factors 18, 20, 24. The operator can ensure that the customer programmable parameter 30 overrides the dynamic offset factors 18, 20, 24 generated from the horizon map 12; the road grade sensor 14; and the wheel torque and vehicle speed 16. The state of charge routine 26 receives input from the map state of charge limit factor 18, the grade state of charge limit factor 20 and the wheel state of charge limit factor 24, the preset upper and lower state of charge limit boundaries 28 and the customer programmable parameter 30 and outputs a dynamically adjusting state of charge limit percentage. The state of charge routine 26 outputs a final

maximum charge limit to a charging system 32.

While particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed:

1. A method of providing an intelligent charge limit for a battery in a vehicle, comprising the steps of:

utilizing at least one of horizon map data, a road grade sensor, wheel torque and vehicle speed, said horizon map data includes data of downhill segments in a travel route, said road grade sensor provides a slope of the travel route either positive or negative;

calculating dynamically a percentage of a maximum charge limit to create a dynamic maximum charge limit for a battery based on at least one of said horizon map data, said road grade sensor, wheel torque and vehicle speed;

providing a minimum low boundary percentage charge limit and a high maximum boundary percentage charge limit; and

combining said dynamic maximum charge limit with said high and low minimum boundary percentage charge limit to define a maximum charge limit for charging the battery.

2. The method of providing an intelligent charge limit of claim 1, further comprising the step of:

inputting data based on previous trips on the same travel route to calculate said maximum charge limit.

3. The method of providing an intelligent charge limit of claim 1, further comprising the step of:

utilizing weight of a vehicle to determine a charge limit percentage.

4. A method of providing an intelligent charge limit for a battery in a vehicle, comprising the steps of:

utilizing at least one of horizon map data, a road grade sensor, wheel torque and vehicle speed, said horizon map data includes data of downhill segments in a travel route, said road grade sensor provides a slope of the travel route either positive or negative;

calculating dynamically a percentage of a maximum charge limit to create a dynamic maximum charge limit for a battery based on at least one of said horizon map data, said road grade sensor, wheel torque and vehicle speed;

inputting an operator maximum charge limit entered by a user;

offsetting said operator maximum charge limit with said dynamic maximum charge limit to define a maximum charge limit for charging the battery.

5. The method of providing an intelligent charge limit of claim 4, further comprising the step of:

providing a minimum low boundary percentage charge limit and a high maximum boundary percentage charge limit as a reference.

6. The method of providing an intelligent charge limit of claim 5, further comprising the step of:

using said high and low maximum boundary percentage charge limit for calculating said maximum charge limit.

7. The method of providing an intelligent charge limit of claim 6, further comprising the step of:

entering said high and low maximum boundary percentage charge limit with one of a customer programmable parameter or an HMI device.

8. The method of providing an intelligent charge limit of claim 4, further comprising the step of:

inputting data based on previous trips on the same travel route to calculate said maximum charge limit.

9. The method of providing an intelligent charge limit of claim 4, further comprising the step of:

utilizing a weight of a vehicle to determine a charge limit percentage.

10. A method of providing an intelligent charge limit for a battery in a vehicle, comprising the steps of:

utilizing at least one of horizon map data, a road grade sensor, wheel torque and vehicle speed, said horizon map data includes data of downhill segments in a travel route, said road grade sensor provides a slope of the travel route either positive or negative;

calculating dynamically a percentage of a maximum charge limit to create a dynamic maximum charge limit for a battery based on at least one of said horizon map data, said road grade sensor, wheel torque and vehicle speed;

inputting an operator maximum charge limit entered by a user;

re-plugging a charge gun at a charge station to eliminate said dynamic maximum charge limit from being used in calculating a maximum charge limit for charging the battery.

11. The method of providing an intelligent charge limit of claim 9, further comprising the step of:

inputting data based on previous trips on the same travel route.

12. The method of providing an intelligent charge limit of claim 11, further comprising the step of:

providing a minimum low boundary percentage charge limit and a high maximum boundary percentage charge limit as a reference.

13. The method of providing an intelligent charge limit of claim 12, further comprising the step of:

using said high and low maximum boundary percentage charge limit for calculating said maximum charge limit.

14. The method of providing an intelligent charge limit of claim 13, further comprising the step of:

entering said high and low maximum boundary percentage charge limit with one of a customer programmable parameter or an HMI device.

15. The method of providing an intelligent charge limit of claim 10, further comprising the step of:

utilizing a weight of a vehicle to determine a charge limit percentage.

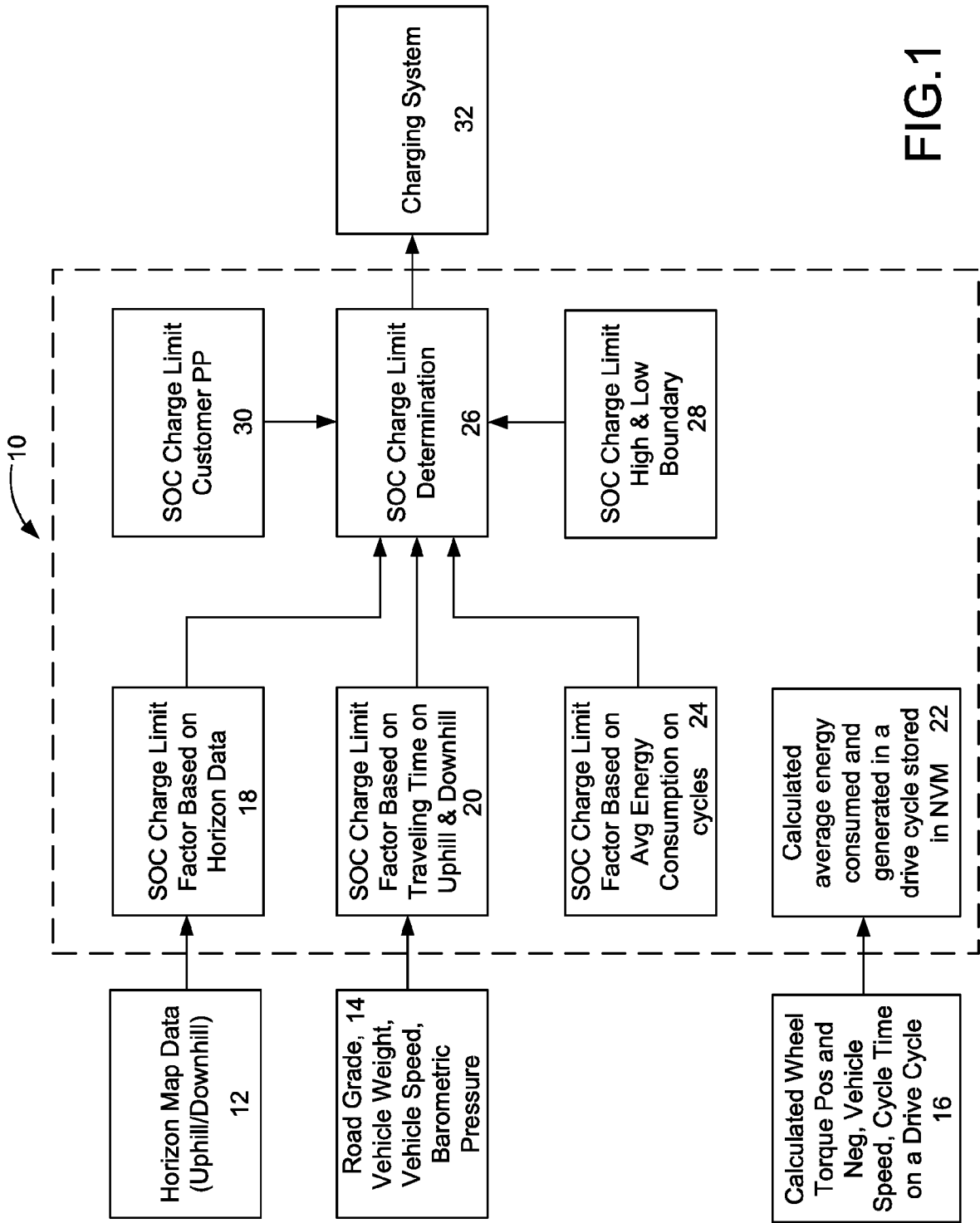
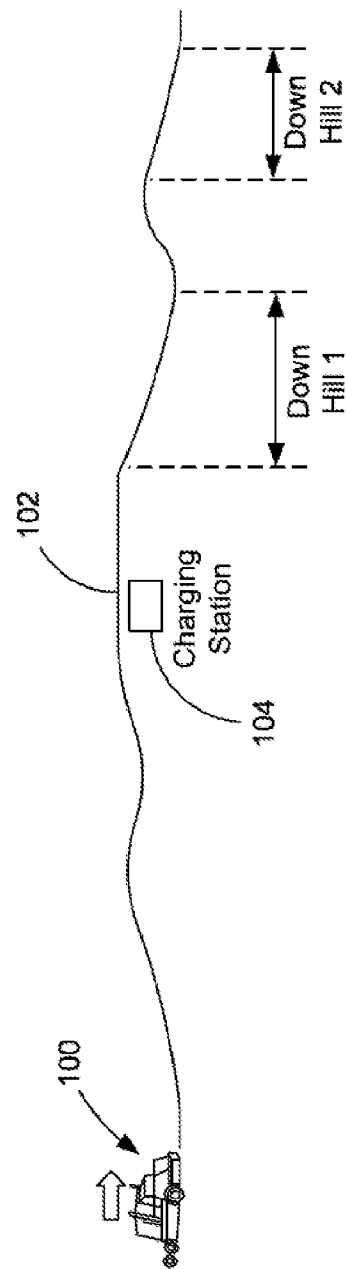


FIG.1



Down Hills will provide an opportunity to recuperate energy with regen

FIG.2

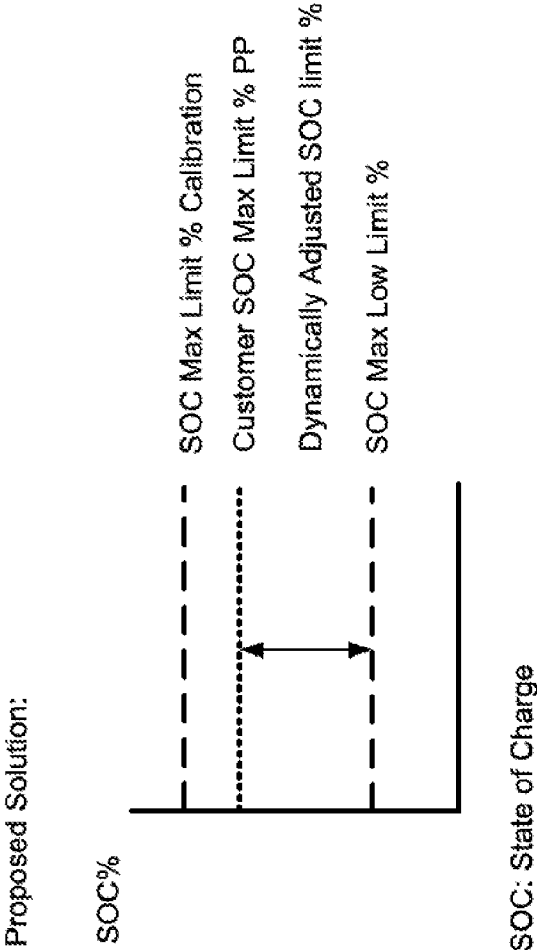


FIG.3

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2023/023042

A. CLASSIFICATION OF SUBJECT MATTER INV. B60L7/18 B60L58/13 B60L58/14 B60L58/15 B60L53/14 B60L53/31 ADD. According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) B60L Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2016/243958 A1 (MILLER KENNETH JAMES [US] ET AL) 25 August 2016 (2016-08-25) the whole document -----	1-3
A	US 2021/380010 A1 (ANDO EISHO [JP]) 9 December 2021 (2021-12-09) paragraphs [0028] - [0029]; figures 2-3 -----	1-3
A	US 10 442 313 B2 (MEDATECH ENG SERVICES LTD [CA]) 15 October 2019 (2019-10-15) claim 1; figure 3 -----	1-3
A	US 2021/061120 A1 (PARK DAE RO [KR] ET AL) 4 March 2021 (2021-03-04) claims 4-5, 9; figure 5 ----- --/--	1-3
☒ 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 25 July 2023		Date of mailing of the international search report 09/10/2023
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Chevret, Anthony

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2023/023042

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims;; it is covered by claims Nos.:

1-3

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2023/023042

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2017/120762 A1 (ZETTEL ANDREW M [CA] ET AL) 4 May 2017 (2017-05-04) paragraph [0027]; claims 1-3 -----	1-3
A	US 9 481 359 B2 (TOYOTA MOTOR CO LTD [JP]) 1 November 2016 (2016-11-01) figure 6 -----	1-3
A	US 2018/273021 A1 (MORIMOTO YOUHEI [JP] ET AL) 27 September 2018 (2018-09-27) figure 2 -----	1-3

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2023/023042

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2016243958 A1	25-08-2016	CN 105905107 A DE 102016102825 A1 US 2016243958 A1	31-08-2016 25-08-2016 25-08-2016
US 2021380010 A1	09-12-2021	JP 6972375 B2 JP WO2020079728 A1 US 2021380010 A1 WO 2020079728 A1	24-11-2021 30-04-2021 09-12-2021 23-04-2020
US 10442313 B2	15-10-2019	CA 2982997 A1 US 2018111496 A1	21-04-2018 26-04-2018
US 2021061120 A1	04-03-2021	KR 20210026400 A US 2021061120 A1	10-03-2021 04-03-2021
US 2017120762 A1	04-05-2017	CN 106627561 A DE 102016119724 A1 US 2017120762 A1	10-05-2017 04-05-2017 04-05-2017
US 9481359 B2	01-11-2016	CN 105564422 A EP 3015333 A1 JP 2016084061 A US 2016114786 A1	11-05-2016 04-05-2016 19-05-2016 28-04-2016
US 2018273021 A1	27-09-2018	CN 108349486 A DE 112016005098 T5 JP 6406215 B2 JP 2017087915 A US 2018273021 A1 WO 2017077808 A1	31-07-2018 02-08-2018 17-10-2018 25-05-2017 27-09-2018 11-05-2017

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-3

The technical features of these claims form a 1st group of inventions, whose aim is inexistent due to the special technical features consisting in a minimum low boundary percentage charge limit which is allegedly used to determine a maximum value. It is however unclear how a minimum value can be used to determine a maximum value.

2. claims: 4-9

The technical features of these claims form a 2nd group of inventions, whose aim is to solve problems related to safety margin especially via special technical features consisting in that the maximum charge limit is an input from a user and the combination is an offset.

3. claims: 10-15

The technical features of these claims form a 3rd group of inventions, whose aim is to solve problems related to the non usage of charging limit especially via special technical features consisting in re-plugging a charge gun at a charge station to eliminate said dynamic maximum charge limit from being used in calculating a maximum charge limit for charging the battery.

NB: the operator maximum charge limit entered by a user is never used on claim 10.
