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BATTERY REUSE MANAGEMENT SYSTEM

Abstract

A battery reuse management system includes a stationary electrical storage device and an information management apparatus. The stationary electrical storage device includes a plurality of in-vehicle battery packs at least one or some of which have been primarily used. The information management apparatus is configured to receive, from the stationary electrical storage device, battery management information on each of the plurality of in-vehicle battery packs and manage the battery management information. The battery management information includes travel distance information indicating a total travel distance that a vehicle has travelled when a corresponding one of the in-vehicle battery packs is mounted on the vehicle. The information management apparatus is configured to execute a pack identification process of identifying the in-vehicle battery pack corresponding to the battery management information based on the travel distance information.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Japanese Patent Application No. 2024-022653 filed on Feb. 19, 2024, incorporated herein by reference in its entirety.

BACKGROUND

1. Technical Field

[0002] The disclosure relates to a technology to manage the reuse of an in-vehicle battery pack.

2. Description of Related Art

[0003] WO 2012/043592 describes a power supply unit including a plurality of function modules and a main controller. Each of the function modules includes a battery block made up of a plurality of battery cells, a communication interface, a memory unit, and a battery status detecting unit. When a function module is connected to the main controller, unique address information is assigned to the function module from the main controller. The function module records the assigned unique address information in the memory unit and performs data communication based on the address information.

[0004] WO 2002/067347 describes a battery pack including unique address and a communication device to a network so that the battery pack itself can connect with the network. Japanese Unexamined Patent Application Publication No. 2017-175858 (JP 2017-175858 A) describes a storage battery management apparatus that, at a startup of an electrical storage system, detects that a battery pack is attached and assigns a management number for identifying the battery pack.

SUMMARY

[0005] When a battery reuse management system includes a stationary electrical storage device including a plurality of in-vehicle battery packs at least partially primarily used and an information management apparatus that receives, from the stationary electrical storage device, battery management information on each of the in-vehicle battery packs and manages the battery management information, the battery reuse management system has the following task. It is desirable that a correspondence between battery management information transmitted from the stationary electrical storage device to the information management apparatus and an in-vehicle battery pack not become unknown.

[0006] A battery reuse management system according to the disclosure includes a stationary electrical storage device and an information management apparatus. The stationary electrical storage device includes a plurality of in-vehicle battery packs at least one or some of which have been primarily used. The information management apparatus is configured to receive, from the stationary electrical storage device, battery management information on each of the plurality of in-vehicle battery packs and manage the battery management information. The battery management information includes travel distance information indicating a total travel distance that a vehicle has travelled when a corresponding one of the in-vehicle battery packs is mounted on the vehicle. The information management apparatus is configured to execute a pack identification process of identifying the in-vehicle battery pack corresponding to the battery management information based on the travel distance information.

[0007] When in-vehicle battery packs have been primarily used in vehicles, travel distance information when each in-vehicle battery pack is primarily used is unique to the in-vehicle battery

pack. Even when the in-vehicle battery pack is reused in a stationary electrical storage device thereafter, the travel distance information remains unchanged from that when the in-vehicle battery pack is primarily used. For this reason, with the use of travel distance information, it is possible to make it easy to identify an in-vehicle battery pack corresponding to battery management information from the stationary electrical storage device.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Features, advantages, and technical and industrial significance of exemplary embodiments of the disclosure will be described below with reference to the accompanying drawings, in which like signs denote like elements, and wherein:

[0009] FIG. **1** is a conceptual diagram for illustrating a general outline of a battery reuse management system according to an embodiment;

[0010] FIG. **2** is a conceptual diagram for illustrating information related to the reuse of an in-vehicle battery pack;

[0011] FIG. **3** is a block diagram that shows a configuration example of an information management apparatus and a battery use system;

[0012] FIG. **4** is a diagram for specifically illustrating a task related to identification of an in-vehicle battery pack corresponding to battery management information; and

[0013] FIG. **5** is a flowchart that shows an example of a process related to association (re-association) of an in-vehicle battery pack with a communication instrument having an unknown MAC address.

DETAILED DESCRIPTION OF EMBODIMENTS

[0014] An embodiment of the disclosure will be described with reference to the accompanying drawings.

1. Battery Reuse Management System

[0015] FIG. **1** is a conceptual diagram for illustrating a general outline of a battery reuse management system **1** according to the present embodiment. The battery reuse management system **1** manages the reuse of a battery pack **10**. Reuse is a concept including secondary use, tertiary use, ... Particularly, the battery reuse management system **1** manages the reuse of the battery pack (in-vehicle battery pack) **10** mounted on a vehicle **100**. The vehicle **100** is a battery electric vehicle (BEV) or a hybrid electric vehicle (HEV or PHEV) that uses an electric motor as a driving power unit. The battery pack **10** is mounted on the vehicle **100**. The electric motor is driven by electric power supplied from the battery pack **10**.

[0016] The battery reuse management system **1** includes one or more vehicles **100** and an information management apparatus **300**. The information management apparatus **300** serves as an information platform that manages various pieces of information. The information management apparatus **300** includes one or more servers. The information management apparatus **300** may be made up of a plurality of servers that execute distributed processing. Each vehicle **100** and the information management apparatus **300** are communicable with each other via a wireless communication network.

[0017] The vehicle **100** may periodically transmit vehicle information on the vehicle **100** to the information management apparatus **300**. The vehicle information may include travel history information TRV indicating the travel history of the vehicle **100**. For example, the travel history information TRV includes a total travel distance of the vehicle **100**. In another example, the travel history information TRV may include location history information of the vehicle **100**.

[0018] The vehicle information may include battery information BAT reflecting a usage history of the battery pack **10**. For example, the battery information BAT includes battery usage history

information. The battery usage history information includes, for example, at least one of a temperature history, a state-of-charge (SOC) history, a current history, a voltage history, and a charge history. Each history may be expressed by a frequency distribution. The battery information BAT may include a state of health (SOH).
[0019] The SOH may be calculated based on battery usage history information. The battery information BAT may include a total charge electricity amount and/or a total discharge electricity amount. The battery information BAT may include a battery capacity and/or a battery output.
[0020] The battery reuse management system **1** may further include a terminal **200** that is used at a vehicle dealer or a vehicle repair factory. At a vehicle dealer or a vehicle repair factory, the above-described vehicle information can be read from the vehicle **100** with a predetermined tool. The vehicle information read from the vehicle **100** is input to the terminal **200**. In other words, the terminal **200** can also acquire the vehicle information. The terminal **200** is communicable with the information management apparatus **300** via a wireless or wired communication network. The terminal **200** may transmit vehicle information read from the vehicle **100** to the information management apparatus **300**.
[0021] The information management apparatus **300** collects, accumulates, and manages vehicle information on a large number of vehicles **100**. The information management apparatus **300** includes a vehicle information database **320** that accumulates vehicle information on a large number of vehicles **100**. The vehicle information database **320** is implemented by one or more storage devices.
[0022] Next, the reuse of the battery packs **10** that have been mounted on the vehicles **100** will be described. The battery packs **10** are taken out from the vehicles **100** and reused.
[0023] A battery use system **500** is a system that uses a storage battery. For example, the battery use system **500** is a stationary storage battery system that accumulates renewable energy in a stationary storage battery. In another example, the battery use system **500** may be a home power supply system using a stationary storage battery. According to the present embodiment, the battery packs (in-vehicle battery packs) **10** that have been mounted on the vehicles **100** are reused as a stationary electrical storage device **520** (described later) in such a battery use system **500**. A large number of battery packs **10** are provided from a large number of vehicles **100**, so cost reduction of the battery use system **500** is facilitated, and proliferation of the battery use system **500** is facilitated.
[0024] FIG. **2** is a conceptual diagram for illustrating information related to the reuse of the battery pack **10**. The battery pack **10** includes one or more battery modules **11** and a controller **12** for controlling the battery pack **10**. The controller **12** is also called electronic control unit (ECU).
[0025] In reusing the battery pack **10**, the battery reuse management system **1** acquires primary use information PU. The primary use information PU corresponds to vehicle information when the battery pack **10** is primarily used in the vehicle **100**.
[0026] For example, the primary use information PU includes battery information BAT reflecting the usage history of the battery pack **10** primarily used in the vehicle **100**. The battery information BAT is stored in the controller **12** (ECU) in the battery pack **10** and is read from the controller **12**. For example, just before the battery pack **10** is taken out from the vehicle **100**, an information processing device of the vehicle **100** acquires the battery information BAT from the controller **12** in the battery pack **10** and transmits the battery information BAT to the information management apparatus **300**. In another example, at a vehicle dealer or a vehicle repair factory, the battery information BAT may be read from the controller **12** (ECU) in the battery pack **10** with a predetermined tool. In this case, the terminal **200** acquires the battery information BAT, and transmits the battery information BAT to the information management apparatus **300**. In another example, the information management apparatus **300** may acquire the battery information BAT of the vehicle **100** from the vehicle information database **320**.
[0027] The primary use information PU may include travel history information TRV of the vehicle **100** on which the battery pack **10** has been mounted. The travel history information TRV includes

travel distance information indicating a total travel distance of the vehicle **100**. The travel history information TRV may also include location history information. The total travel distance information is stored in the controller **12** in the battery pack **10** or a storage device of an in-vehicle system. The location history information is obtained from the storage device of the in-vehicle system or the vehicle information database **320** of the information management apparatus **300**. The information management apparatus **300** acquires the travel history information TRV with a method similar to the above-described method of acquiring the battery information BAT.

[0028] Battery management information **30** is information that is used when the battery pack **10** is reused. The battery management information **30** is generated based on the primary use information PU. More specifically, the battery management information **30** includes the battery information BAT and the travel history information TRV. There are various environments (ambient temperature, humidity, and the like) of regions where the vehicle **100** has travelled, and the degradation condition of battery performance varies depending on an environment, so the travel history information TRV can also be useful information when the battery pack **10** is reused. The battery management information **30** may include the vehicle type of the vehicle **100** on which the battery pack **10** has been mounted. The battery management information **30** may be generated in any one of the vehicle **100**, the terminal **200**, and the information management apparatus **300**.

[0029] The information management apparatus **300** collects, accumulates, and manages pieces of battery management information **30** on a large number of vehicles **100**. The information management apparatus **300** includes a battery management information database **330** that accumulates the pieces of battery management information **30** on a large number of vehicles **100** (see FIG. **1**). The battery management information database **330** is implemented by one or more storage devices.

[0030] Reuse identification information (hereinafter, referred to as “reuse ID”) is identification information of the battery pack **10** reused. The details of the reuse ID will be described later. The reuse ID is associated with the battery pack **10**. For example, a peel-off sticker or the like with printed two-dimensional code indicating the reuse ID is attached to the battery pack **10**. QR code (registered trademark) is illustrated as two-dimensional code. More specifically, at a vehicle dealer or a vehicle repair factory, an operator takes out the battery pack **10** from the vehicle **100**. A reuse ID is generated by the terminal **200** or the operator. The operator attaches a peel-off sticker or the like with printed two-dimensional code indicating the reuse ID to the battery pack **10**. The terminal **200** associates the reuse ID with the primary use information PU or the battery management information **30** and transmits the reuse ID and the primary use information PU or the battery management information **30** to the information management apparatus **300**.

[0031] In this way, the information management apparatus **300** acquires the reuse ID and the battery management information **30** of the battery pack **10**. The information management apparatus **300** associates the reuse ID with the battery management information **30** in the battery management information database **330**. In other words, the information management apparatus **300** manages the reuse ID and the battery management information **30** in association with each other.

[0032] The battery pack **10** taken out from the vehicle **100** is provided to a user that reuses the battery pack **10** (hereinafter, referred to as “reuse user” or “reuser”). The reuse user is an operator of the battery use system **500**. The information management apparatus **300** provides the reuse ID and the battery management information **30** to the reuse user in association with each other. In other words, a set of three pieces, that is, the battery pack **10**, the reuse ID of the battery pack **10**, and the battery management information **30** on the battery pack **10**, are provided to the reuse user. In other words, the battery pack **10** and the battery management information **30** are associated with the reuse ID and provided to the reuse user.

[0033] More specifically, the battery use system **500** includes an information collecting apparatus **510**. The information collecting apparatus **510** is communicable with the information management apparatus **300** via a wired or wireless communication network. The information management

apparatus **300** transmits the reuse ID and the battery management information **30** of the battery pack **10** to the information collecting apparatus **510** of the battery use system **500** in which the battery pack **10** is reused. The information collecting apparatus **510** manages the reuse ID and the battery management information **30** in association with each other. On the other hand, two-dimensional code indicating the reuse ID of the battery pack **10** is attached to the battery pack **10**. Therefore, in the battery use system **500**, the battery pack **10**, the reuse ID, and the battery management information **30** are associated with one another.

[0034] When the battery pack **10** is reused in the battery use system **500**, the information collecting apparatus **510** monitors the status of use of the battery pack **10** and adds battery usage history information on the battery pack **10** to the battery management information **30** (battery information BAT). As a result, the battery management information **30** includes not only the battery information BAT when the battery pack **10** is primarily used in the vehicle **100** but also the battery information BAT when the battery pack **10** is reused in the battery use system **500**. In this way, the battery usage history information reflects not only the usage history of the battery pack **10** when primarily used in the vehicle **100** but also the usage history of the battery pack **10** when reused.

[0035] The information collecting apparatus **510** periodically uploads (transmits) the latest battery management information **30** to the information management apparatus **300** together with the reuse ID. The information management apparatus **300** periodically acquires the latest battery management information **30** and the reuse ID. The information management apparatus **300** updates the battery management information **30** associated with the reuse ID in the battery management information database **330** with the latest one.

[0036] FIG. **3** is a block diagram that shows a configuration example of the information management apparatus **300** and the battery use system **500**.

[0037] The information management apparatus **300** includes an information processing device **310** in addition to the vehicle information database **320** and the battery management information database **330** (see FIG. **1**). The information processing device **310** is allowed to access the vehicle information database **320** and the battery management information database **330**. The information processing device **310** stores various pieces of information, executes various pieces of information processing, and communicates with external sources via a communication interface. The information processing device **310** includes one or more processors (processing circuits) and one or more storage devices. The functions of the information processing device **310** may be implemented by cooperation of the processor(s) running a control program with the storage device(s). The control program is stored in the storage device(s). Alternatively, the control program may be recorded on a computer-readable recording medium.

[0038] The battery use system **500** includes the stationary electrical storage device **520** together with the information collecting apparatus **510**. The stationary electrical storage device **520** is made up of a combination of a plurality of the battery packs **10**. At least one or some of the battery packs **10** included in the stationary electrical storage device **520** have been primarily used, that is, at least one or some of the battery packs **10** included in the stationary electrical storage device **520** are used products that have been mounted on the vehicle **100** and used. For example, all the battery packs **10** included in the stationary electrical storage device **520** may have been primarily used.

[0039] In an example shown in FIG. **3**, the stationary electrical storage device **520** includes **60** battery packs **10**. Specifically, the **60** battery packs **10** are configured as **20** sets of battery packs **10** in total where three battery packs **10** are configured as one set. The stationary electrical storage device **520** includes a plurality of communication instruments **521**. The communication instrument **521** is also called a dongle. In the stationary electrical storage device **520**, one communication instrument **521** is provided for one set of three battery packs **10**. In other words, each of the **20** communication instruments **521** is associated with the plurality of (for example, three) battery packs **10** in one set. Each of the communication instruments **521** is communicably connected to the controller **12** included in each of the corresponding battery packs **10**.

[0040] In order to monitor the statuses of use of all the battery packs **10** included in the stationary electrical storage device **520**, the information collecting apparatus **510** communicates with each of the communication instruments **521**, acquires the pieces of battery usage history information of the battery packs **10** in each set, and updates the pieces of battery management information **30**. As already described above, the information collecting apparatus **510** transmits the latest battery management information **30** to the information management apparatus **300** together with the reuse ID. In other words, each of the communication instruments **521** transmits the pieces of battery management information **30** and the reuse IDs of the three battery packs **10** associated with itself to the information management apparatus **300** via the information collecting apparatus **510**. This transmission is performed for each individual battery pack **10**.

[0041] In the present embodiment, the reuse ID (reuse identification information) is determined as follows. A unique address is assigned to each communication instrument **521**. The address is a media access control address (MAC address). Specifically, MAC addresses **01** to **20** are respectively assigned to the **20** communication instruments **521** included in the stationary electrical storage device **520**. For the sake of convenience of description, the MAC addresses are expressed by two-digit numerals shorter than actual MAC addresses. Then, battery pack IDs (pack identification information) are assigned to all the battery packs **10** included in the stationary electrical storage device **520**. Specifically, battery pack IDs A, B, and C are respectively assigned to the three battery packs **10** in each set. In other words, battery pack IDs do not overlap among the three battery packs **10** associated with the same communication instrument **521** and are numbered in accordance with a common rule on an individual communication instrument **521** basis. Then, as shown in FIG. **3**, the reuse ID is a combination (for example, **01**-A) of the MAC address (for example, **01**) of the communication instrument **521** with the battery pack ID (for example, A) of the battery pack **10** associated with the communication instrument **521**.

2. Identifying Battery Pack Corresponding to Battery Management Information

[0042] In the battery reuse management system **1**, it is desirable that a correspondence between the battery management information **30** transmitted from the stationary electrical storage device **520** to the information management apparatus **300** and the battery pack (in-vehicle battery pack) **10** not become unknown. In other words, the information management apparatus **300** is desired to be capable of easily identifying the battery pack **10** corresponding to the battery management information **30** transmitted from the stationary electrical storage device **520**.

[0043] FIG. **4** is a diagram for specifically illustrating a task related to identification of the battery pack **10** corresponding to the battery management information **30**. In FIG. **4**, as in the case of the example shown in FIG. **3**, the stationary electrical storage device **520** including **20** sets of one communication instrument **521** and three battery packs **10** is illustrated.

[0044] In FIG. **4**, “during normal times” corresponds to when, for all the battery packs **10**, combinations of the reuse ID and the battery management information **30**, held by the information management apparatus **300**, are transmitted from the stationary electrical storage device **520** to the information management apparatus **300** via the information collecting apparatus **510**.

[0045] On the other hand, when a plurality of communication instruments **521** has been replaced for reasons, such as failure, after the last transmission of the pieces of battery management information **30**, pieces of battery management information **30** received by the information management apparatus **300** include pieces of battery management information **30** on battery packs **10** to which the reuse IDs (such as **21**-A) including the MAC addresses of the communication instruments **521** after replacement are assigned. The MAC addresses of the communication instruments **521** after replacement are unknown MAC addresses for the information management apparatus **300**.

[0046] If the number of communication instruments **521** having an unknown MAC address is one, it may be determined that the communication instrument **521** having a MAC address included at the last transmission of the battery management information **30** and not received this time has been

replaced with the communication instrument **521** having the unknown MAC address. In this case, the information management apparatus **300** updates the reuse IDs such that three battery packs **10** associated with the communication instrument **521** having a MAC address not received this time are associated with the communication instrument **521** having the unknown MAC address. Thus, the information management apparatus **300** can continuously identify the three battery packs **10** with the updated reuse IDs. Then, the information management apparatus **300** can continuously acquire the pieces of battery management information **30** of the three battery packs **10** by associating the updated reuse IDs with the pieces of battery management information **30** of the three battery packs **10**.

[0047] On the other hand, when, for example, a plurality of the communication instruments **521** is replaced at the same time, the reuse IDs transmitted from the stationary electrical storage device **520** include six or more reuse IDs each having an unknown MAC address. If the number of unknown MAC addresses becomes two or more in this way, it is not possible to identify which unknown MAC addresses correspond to which two or more MAC addresses not received this time. In other words, it is not possible to identify the battery packs **10** to which the reuse IDs including these unknown MAC addresses are assigned. More specifically, FIG. **4** shows an example in which three unknown MAC addresses **21**, **22**, **23** are included. In this example, it is necessary to take measures for identifying a correspondence between three MAC addresses **02**, **03**, **19** not received this time and three unknown MAC addresses **21**, **22**, **23**.

[0048] Then, in the present embodiment, the information management apparatus **300** executes a pack identification process. The pack identification process is a process of identifying the battery pack **10** corresponding to the battery management information **30** based on travel distance information. The travel distance information used in the pack identification process is included in the battery management information **30** received from the stationary electrical storage device **520** for each individual battery pack **10**.

[0049] Specifically, in the pack identification process, when the MAC addresses of the plurality of communication instruments **521**, received from the stationary electrical storage device **520**, include a plurality of unreceived MAC addresses and a plurality of unknown MAC address as many as the plurality of unreceived MAC addresses, the information management apparatus **300** identifies the plurality of unknown MAC addresses respectively corresponding to the plurality of unreceived MAC addresses based on travel distance information. Then, the information management apparatus **300** associates the battery packs **10** that have been respectively associated with the plurality of communication instruments **521** having the plurality of unreceived MAC addresses with the plurality of communication instruments **521** having the plurality of unknown MAC addresses identified.

[0050] In the pack identification process, when it is not possible to identify a plurality of unknown MAC addresses respectively corresponding to a plurality of unreceived MAC addresses based on travel distance information, the information management apparatus **300** performs the identification based on battery usage history information.

2-1. Example of Process

[0051] FIG. **5** is a flowchart that shows an example of a process related to association (re-association) of battery packs **10** with communication instruments **521** having unknown MAC addresses. Processes P**1**, P**2**, P**3**, P**4**, P**5**, P**6**, P**7**, P**8** in FIG. **5** each are a process related to re-association of battery packs **10** and are included in the pack identification process.

[0052] In step S**100**, the information processing device (or simply the device) **310** of the information management apparatus **300** determines whether information (reuse ID and battery management information **30**) on each individual battery pack **10** from the stationary electrical storage device **520** has been received. More specifically, the information is received in order of the battery pack IDs of A, B, and C for each communication instrument **521**. When the received information includes unknown MAC addresses (Yes in step $**102**), the process proceeds to step

S**104**.
[0053] In step S**104**, the device **310** determines whether the number of unknown MAC addresses is one. As a result, when the number of unknown MAC addresses is one, the device **310** executes the process PI (step S**106**). In the process P**1**, the device **310** cancels the reuse IDs including the MAC address not received this time and updates (re-associates) the reuse IDs of the three battery packs **10**, to which the cancelled reuse IDs have been assigned, with reuse IDs including a MAC address newly received this time. For example, when the MAC address **02** is not received and the MAC address **21** is newly received, the reuse IDs of the three battery packs **10**, to which the reuse IDs **02**-A, **02**-B, and **02**-C are assigned, are updated with the reuse IDs **21**-A, **21**-B, and **21**-C.
[0054] On the other hand, when the number of unknown MAC addresses is two or more (No in step S**104**), the device **310** determines whether a determination condition C**1** is satisfied (step S**108**). In the following description, for the sake of convenience, the battery packs **10** having the battery pack IDs of A, B, and C are respectively referred to as battery packs **10**A, **10**B, **10**C.
[0055] The determination condition C**1** is that, of the battery packs **10** associated with two or more MAC addresses not received this time, the number of the battery packs **10**A of which the total travel distance at the last reception is zero is one or zero. The travel distance information includes the numeric value of the total travel distance of the battery pack **10** not primarily used in the vehicle **100** (that is, a new battery pack **10**) as zero.
[0056] When the determination condition C**1** is satisfied, the device **310** determines whether a determination condition C**2** is satisfied (step S**110**). The determination condition C**2** is that the numeric values of the total travel distances of the battery packs **10**A respectively associated with the two or more MAC addresses not received this time all are different. When the determination condition C**2** is satisfied, the device **310** executes the process P**2** (step S**112**).
[0057] In the process P**2**, the device **310** refers to the travel distance information included in the battery management information **30** of each of the intended battery packs **10**. Specifically, the device **310** searches for pairs in which the total travel distance matches between the battery packs **10**A associated with the MAC addresses not received this time and the battery packs **10**A associated with the unknown MAC addresses newly received this time. The number of pairs is equal to the number of MAC addresses not received this time and also equal to the number of unknown MAC addresses. For each searched pair, the device **310** updates (re-associates) the reuse IDs such that the MAC address not received this time is replaced with the MAC address newly received this time. When, for example, the total travel distances of three battery packs **10**A having the MAC addresses of **02**, **03**, and **19** not received this time are respectively X, Y, and Z and the total travel distances of battery packs **10**A having unknown MAC addresses **21**, **22**, and **23** are respectively Y, X, and Z, re-association is performed as follows. The MAC address of **02** is replaced with **22**, **03** is replaced with **21**, and **19** is replaced with **23**.
[0058] On the other hand, when the determination condition C**2** is not satisfied, that is, when the numeric values of the total travel distances overlap among the battery packs **10**A associated with MAC addresses not received this time, the device **310** determines whether a determination condition C**3** is satisfied (step S**114**). The determination condition C**3** is that a combination of the numeric values of the total travel distances of the battery packs **10**B, **10**C associated with each individual MAC address not received this time is different among two or more MAC addresses not received this time. When the determination condition C**3** is satisfied, the device **310** executes the process P**3** (step S**116**). For example, the determination condition C**3** is satisfied when combinations of the numeric values of the total travel distances of the three sets of battery packs **10**B, **10**C, respectively associated with three MAC addresses **02**, **03**, and **19** not received this time, are respectively “Y and Z”, “V and W”, and “Z and V”.
[0059] In the process P**3**, the device **310** searches for pairs in which a combination of the total travel distances of the battery packs **10**B, **10**C associated with the MAC address not received this time matches a combination of the total travel distances of the battery packs **10**B, **10**C associated

with the unknown MAC address newly received this time. For each searched pair, the device **310** updates (re-associates) the reuse IDs such that the MAC address not received this time is replaced with the unknown MAC address newly received this time. When, for example, the combinations of the numeric values of the total travel distances of the sets of battery packs **10**B, **10**C, respectively associated with the unknown MAC addresses of **21**, **22**, and **23**, are respectively "V and W", "Y and Z", and "Z and V", re-association is performed as follows. The MAC address of **02** is replaced with **22**, **03** is replaced with **21**, and **19** is replaced with **23**.

[0060] When the determination condition C**3** is not satisfied, that is, when the combinations of the numeric values of the total travel distances of the sets of battery packs **10**A, **10**B, **10**C overlap among the MAC addresses not received this time, the device **310** executes the process P**4** (step S**118**). Initially, for the battery packs **10**B, **10**C of which the combinations of the numeric values of the total travel distances do not overlap among the MAC addresses not received this time, the process P**4** is the same as the process P**3**. Then, for the battery packs **10**A, **10**B, **10**C of which the combinations of the numeric values of the total travel distances overlap, the device **310** uses the battery usage history information (in other words, a battery load history) for re-association. In other words, the device **310** uses at least one (for example, at least one of a temperature history, an SOC history, a current history, a voltage history, and a charge history) of the battery usage history information included in the battery management information **30**.

[0061] Specifically, the device **310** searches for pairs in which continuity in the at least one history of the battery usage history information is recognized between the battery management information **30** at the last reception for the battery packs **10**A, **10**B, **10**C associated with the MAC address not received this time and the battery management information **30** at the current reception for the battery packs **10**A, **10**B, **10**C associated with the unknown MAC address newly received this time. Whether continuity in history is recognized can be determined based on, for example, whether an amount of change of the value of history at the current reception from the value of history at the last reception is less than or equal to a predetermined threshold. Then, for the searched pair as a target (more specifically, for each searched pair when there is a plurality of searched pairs), the device **310** updates the reuse IDs such that the MAC address not received this time is replaced with the unknown MAC address newly received this time. In addition, when each history included in the battery usage history information is expressed by frequency distribution, the frequency of each segment (for example, in the temperature history, a temperature of 30° C. to 31° C., 31°° C. to 32° C., 32° C. to 33° C., . . .) of the frequency distribution monotonously increases every predetermined period of time. For this reason, when data of the frequencies of the MAC addresses not received this time is compared with data of the frequencies of the MAC addresses newly received this time, it is impossible that the numeric values of all the segments in the history (for example, at least one of the temperature history, the SOC history, the current history, and the charge history) reduce. Focusing on this point, it is possible to identify the battery packs **10** by considering the frequency added to the history in an elapsed time from the last reception of the battery management information **30** to the current reception of the battery management information **30**.

[0062] In FIG. **5**, when the determination condition C**1** is not satisfied, that is, when the number of the battery packs **10**A of which the total travel distance at the last reception is zero is two or more among the battery packs **10** associated with two or more MAC addresses not received this time, the device **310** determines whether a determination condition C**4** is satisfied (step S**120**). The determination condition C**4** is the same as the determination condition C**3**. When the determination condition C**4** is satisfied, the device **310** executes the process P**5** (step S**122**). The process P**5** is the same as the process P**3**.

[0063] On the other hand, when the determination condition C**4** is not satisfied, that is, when the combinations of the numeric values of the total travel distances of the battery packs **10**A, **10**B, **10**C overlap among the MAC addresses not received this time, the device **310** executes the process P**6** (step S**124**) and executes the process P**7** (step S**128**) or the process P**8** (step S**130**) according to

whether the determination condition C**5** (step $**126**) is satisfied.
[0064] Specifically, for the battery packs **10**B, **10**C of which the combinations of the numeric values of the total travel distances do not overlap among the MAC addresses not received this time, the process P**6** that is the same as the process P**3** is executed. In addition, even when two or more of the battery packs **10**A associated with two or more MAC addresses not received this time are new but when the combinations of the numeric values of the total travel distances of the battery packs **10**B, **10**C managed by the same MAC addresses of those battery packs **10**A are different among the MAC addresses, re-association is easy.
[0065] On the other hand, for the battery packs **10**A, **10**B, **10**C of which the combinations of the numeric values of the total travel distances overlap, the process P**7** or the process P**8** is executed according to whether the determination condition C**5** is satisfied. The determination condition C**5** is that all the battery packs **10**A, **10**B, **10**C having the overlap combinations of the numeric values of the total travel distances on an individual MAC address not received this time basis are new. The process P**7** that is executed when the determination condition C**5** is satisfied is similar to a process that uses battery usage history information for re-association in the process P**4**. More specifically, even when all the battery packs **10**A, **10**B, **10**C intended for identification are new, various histories (for example, at least one of the temperature history, the current history, and the SOC history) are different on an individual battery pack **10** basis according to a difference in the installation location of the individual battery pack **10** in the stationary electrical storage device **520**. For this reason, focusing on this point, even when the determination condition C**5** is satisfied, re-association is possible.
[0066] The process P**8** that is executed when the determination condition C**5** is not satisfied (that is, when the battery packs **10** having the overlap combinations of the numeric values of the total travel distances on an individual MAC address basis include primarily used battery packs **10**) is a process that uses battery usage history information for re-association similarly to the process P**4** for primarily used battery packs **10**. More specifically, when the determination condition C**5** is not satisfied, it is easy to perform re-association by using battery usage history information by focusing on primarily used battery packs **10** (that is, the battery packs **10** each having a total travel distance (a numeric value other than zero) and actually used in the vehicle **100**).
[0067] In addition, the information management apparatus **300** (information processing device **310**) associates the pieces of battery management information **30**, associated with the reuse IDs before update, with the reuse IDs updated in the process P**1**, the process P**2**, the process P**3**, the process P**4**, the process P**5**, the process P**6**, the process P**7**, or the process P**8** shown in FIG. **5**.
2-2. Advantageous Effects
[0068] When the battery pack **10** is primarily used in the vehicle **100**, travel distance information when the battery pack **10** is primarily used is unique to each battery pack **10**. Even when the battery pack **10** is reused in the stationary electrical storage device **520** thereafter, the travel distance information remains unchanged as that when the battery pack **10** is primarily used. For this reason, with the use of travel distance information, it is possible to make it easy to identify the battery pack **10** corresponding to the battery management information **30** from the stationary electrical storage device **520**.
[0069] More specifically, with the processes P**2**, P**3**, P**5**, and P**6** of the flowchart shown in FIG. **5**, even when a plurality of MAC addresses is not received due to replacement of a plurality of communication instruments **521**, it is possible to identify the communication instruments **521** having a plurality of unknown MAC addresses (that is, the plurality of replaced communication instruments **521**) with the use of the travel distance information. Then, it is possible to continuously identify the battery packs **10** associated with the communication instruments **521** having MAC addresses not received this time.
[0070] When a primarily used battery pack **10** is reused in the vehicle **100**, it is considerably rare that the numeric values of the total travel distances match among the battery packs **10** included in

the stationary electrical storage device **520**. Furthermore, there is presumably an extremely low possibility that a combination of numeric values of the total travel distances of a plurality of battery packs **10** associated with the same communication instrument **521** overlaps among a plurality of communication instruments **521** (among a plurality of MAC addresses). Then, with the processes P**4**, P**7**, and P**8** of the flowchart shown in FIG. **5**, even if it is not possible to identify a plurality of unknown MAC addresses, respectively corresponding to a plurality of MAC addresses not received, based on travel distance information due to the overlap, it is possible to perform the identification with the use of the battery usage history information.

[0071] The number of battery packs **10** associated with each of the communication instruments **521** may be not multiple unlike the case of the example illustrated in FIG. **3** and may be one. However, when the number of battery packs **10** associated with each individual communication instrument **521** is one, the number of communication instruments **521** is enormous if the number of battery packs **10** included in the stationary electrical storage device **520** is large. This can lead to an increase in cost and an increase in communication load of the stationary electrical storage device **520** (first adverse effect). This can also lead to an increase in the frequency of replacement of the communication instrument **521** depending on the durability of the communication instrument **521** (first adverse effect). Conversely, it is conceivable to associate all the battery packs **10** included in the stationary electrical storage device **520** with one communication instrument **521**. However, in this example, as the number of battery packs **10** increases, management of battery pack IDs is complicated (second adverse effect). In contrast, as illustrated in FIG. **3**, by adopting a configuration that a plurality of battery packs **10** is associated with each of a plurality of communication instruments **521**, it is possible to suppress both the first and second adverse effects. In addition, battery pack IDs (pieces of pack identification information) do not overlap among a plurality of battery packs **10** associated with the same communication instrument **521** and are numbered in accordance with a common rule on an individual communication instrument **521** basis. Therefore, it is easy to number a large number of battery packs **10** by using simple battery pack IDs as in the case of the example of A to C in FIG. **3**.

2-3. Another Example of Reuse ID

[0072] In an example in which all the battery packs **10** included in the stationary electrical storage device **520** are primarily used battery packs **10**, the reuse IDs may be travel distance information. In other words, for each individual battery pack **10**, a numeric value of the total travel distance when the battery pack **10** is primarily used may be used as a reuse ID. According to this example, by using travel distance information as a reuse ID, it is possible to easily identify a battery pack **10** corresponding to battery management information **30** from the stationary electrical storage device **520**. In addition, in this example, when numeric values of total travel distances used as reuse IDs overlap among a plurality of battery packs **10**, the reuse IDs may include additional information, such as alphanumeric characters, to identify the plurality of battery packs **10**.

Claims

1. A battery reuse management system comprising: a stationary electrical storage device including a plurality of in-vehicle battery packs at least one or some of which have been primarily used; and an information management apparatus configured to receive, from the stationary electrical storage device, battery management information on each of the plurality of in-vehicle battery packs and manage the battery management information, wherein: the battery management information includes travel distance information indicating a total travel distance that a vehicle has travelled when a corresponding one of the in-vehicle battery packs is mounted on the vehicle; and the information management apparatus is configured to execute a pack identification process of identifying the in-vehicle battery pack corresponding to the battery management information based on the travel distance information.

2. The battery reuse management system according to claim 1, wherein: the stationary electrical storage device includes a plurality of communication instruments each associated with one or more in-vehicle battery packs included in the plurality of in-vehicle battery packs; each of the plurality of communication instruments is configured to transmit, to the information management apparatus, the battery management information of the one or more in-vehicle battery packs associated with the communication instrument and reuse identification information for each individual in-vehicle battery pack; the reuse identification information is identification information of each of the plurality of in-vehicle battery packs during reuse and is a combination of an address unique to each of the plurality of communication instruments with pack identification information assigned to each of the plurality of in-vehicle battery packs; the pieces of pack identification information do not overlap among the one or more in-vehicle battery packs associated with the same communication instrument and are numbered in accordance with a common rule on an individual communication instrument basis; and in the pack identification process, when the addresses of the plurality of communication instruments, received from the stationary electrical storage device, include a plurality of unreceived addresses and a plurality of unknown addresses as many as the plurality of unreceived addresses, the information management apparatus is configured to identify the plurality of unknown addresses respectively corresponding to the plurality of unreceived addresses based on the travel distance information, and respectively associate the plurality of communication instruments having the identified plurality of unknown addresses with the one or more in-vehicle battery packs respectively associated with the plurality of communication instruments having the plurality of unreceived addresses.

3. The battery reuse management system according to claim 2, wherein a plurality of the in-vehicle battery packs is associated with each of the plurality of communication instruments.

4. The battery reuse management system according to claim 2, wherein: the battery management information includes battery usage history information reflecting a usage history of a corresponding one of the in-vehicle battery packs; and in the pack identification process, when the information management apparatus fails to identify the plurality of unknown addresses respectively corresponding to the plurality of unreceived addresses based on the travel distance information, the information management apparatus is configured to identify the plurality of unknown addresses based on the battery usage history information.