US008527132B2

(12) **United States Patent**
Mineta

(10) **Patent No.: US 8,527,132 B2**
(45) **Date of Patent: Sep. 3, 2013**

(54) **ENERGY MAPS AND METHOD OF MAKING**

(75) Inventor: **Kenichi Mineta**, Rancho Palos Verdes, CA (US)

(73) Assignee: **Honda Motor Co., Ltd.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 636 days.

(21) Appl. No.: **12/749,856**

(22) Filed: **Mar. 30, 2010**

(65) **Prior Publication Data**

US 2011/0246019 A1 Oct. 6, 2011

(51) **Int. Cl.**
G06F 19/00 (2011.01)

(52) **U.S. Cl.**
USPC **701/25**; 701/24; 701/123; 701/33.4; 701/32.3; 701/408; 903/903; 700/291

(58) **Field of Classification Search**
USPC 701/22, 24, 25, 65, 94, 123, 33.4, 701/29.3, 31.4, 32.2, 32.3, 32.4, 408; 903/903; 700/291
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,845,227	A	12/1998	Peterson	
7,360,615	B2	4/2008	Salman et al.	
7,761,203	B2 *	7/2010	Yamada	701/33.4
7,849,944	B2 *	12/2010	DeVault	180/65.29
8,103,440	B2 *	1/2012	Sengoku et al.	701/400
8,229,613	B2 *	7/2012	Kato et al.	701/22
2004/0117113	A1	6/2004	Friedrichs et al.	
2005/0228553	A1	10/2005	Tryon	
2006/0278449	A1	12/2006	Torre-Bueno	
2008/0021628	A1	1/2008	Tryon	
2008/0027639	A1	1/2008	Tryon	
2008/0051977	A1	2/2008	Tryon	
2008/0262668	A1	10/2008	Yamada	
2008/0319596	A1	12/2008	Yamada	
2008/0319597	A1	12/2008	Yamada	
2010/0131139	A1 *	5/2010	Sakai et al.	701/22
2011/0130916	A1 *	6/2011	Mayer	701/33

FOREIGN PATENT DOCUMENTS

DE	19831487	3/2000
FR	2811268	1/2002
JP	2001197608	7/2001
JP	2001314004	11/2001
JP	2007312581	11/2007
JP	2008249588	10/2008
WO	2008093454	8/2008

OTHER PUBLICATIONS

Office Action mailed Sep. 9, 2011 in U.S. Appl. No. 12/465,308.
Response to Office Action filed Dec. 21, 2011 in U.S. Appl. No. 12/465,308.

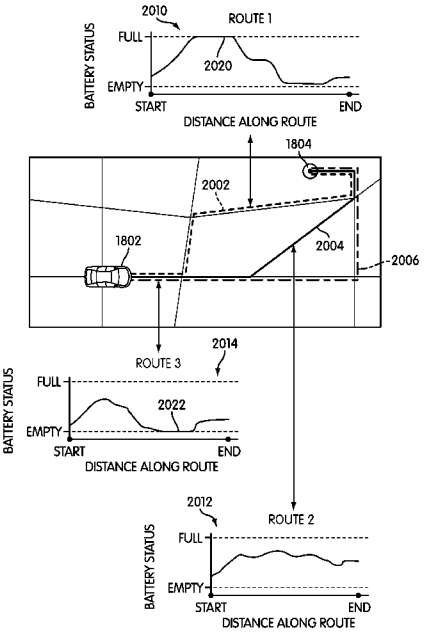
* cited by examiner

Primary Examiner — Ronnie Mancho
(74) *Attorney, Agent, or Firm* — Plumsea Law Group, LLC

(57) **ABSTRACT**

An energy map for a motor vehicle and a method of making the energy map are disclosed. The energy map includes energy information related to energy consumption and energy recharging of various power sources along various roadway segments. A probe vehicle is used to measure energy consumption and energy recharging for various power sources.

39 Claims, 19 Drawing Sheets



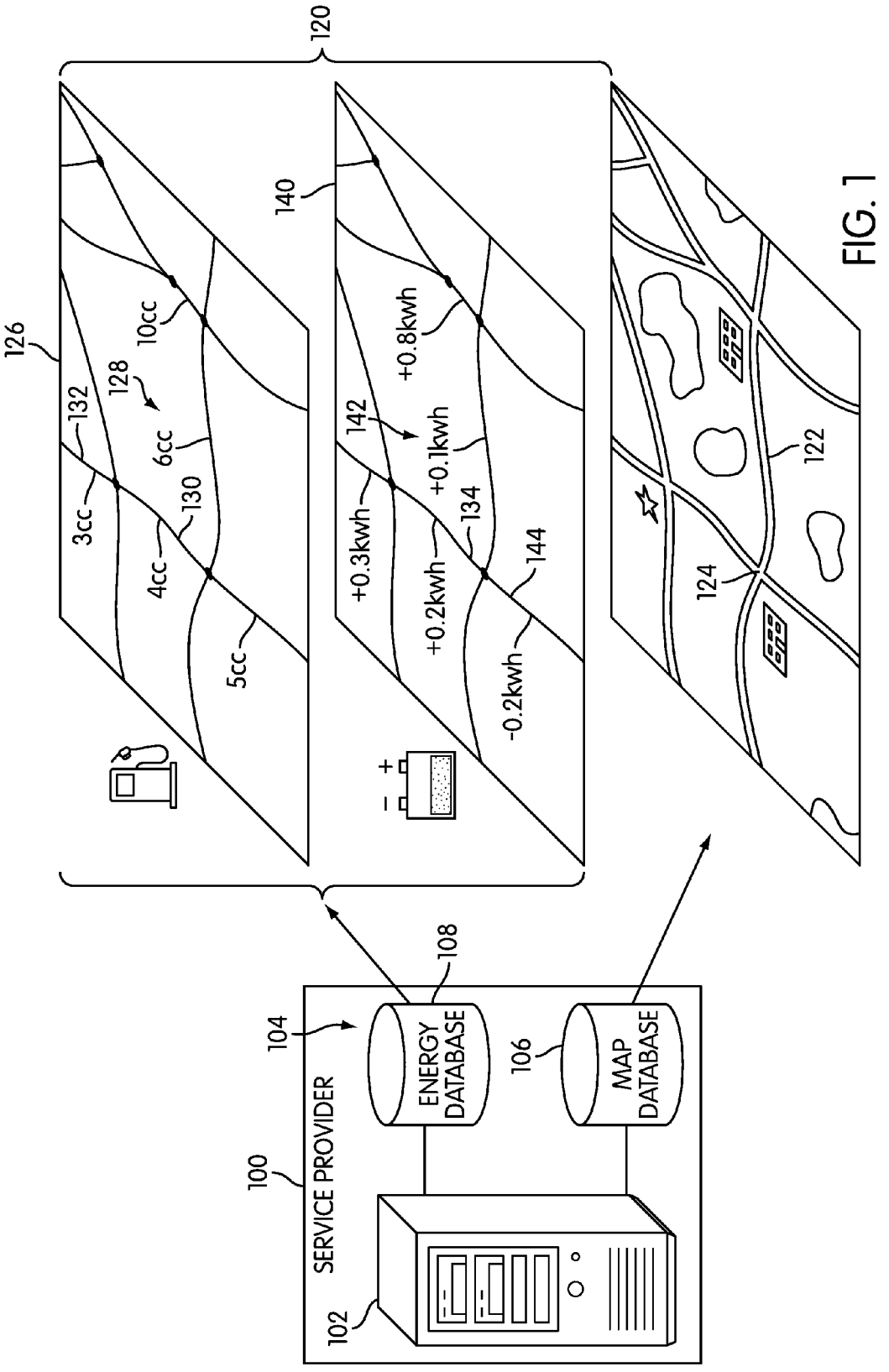

120
126
132
128
10cc
6cc
3cc
130
4cc
5cc
140
142
+0.8kwh
+0.1kwh
+0.3kwh
134
+0.2kwh
144
-0.2kwh
122
124
108
104
ENERGY DATABASE
106
MAP DATABASE
100
SERVICE PROVIDER
102

FIG. 1

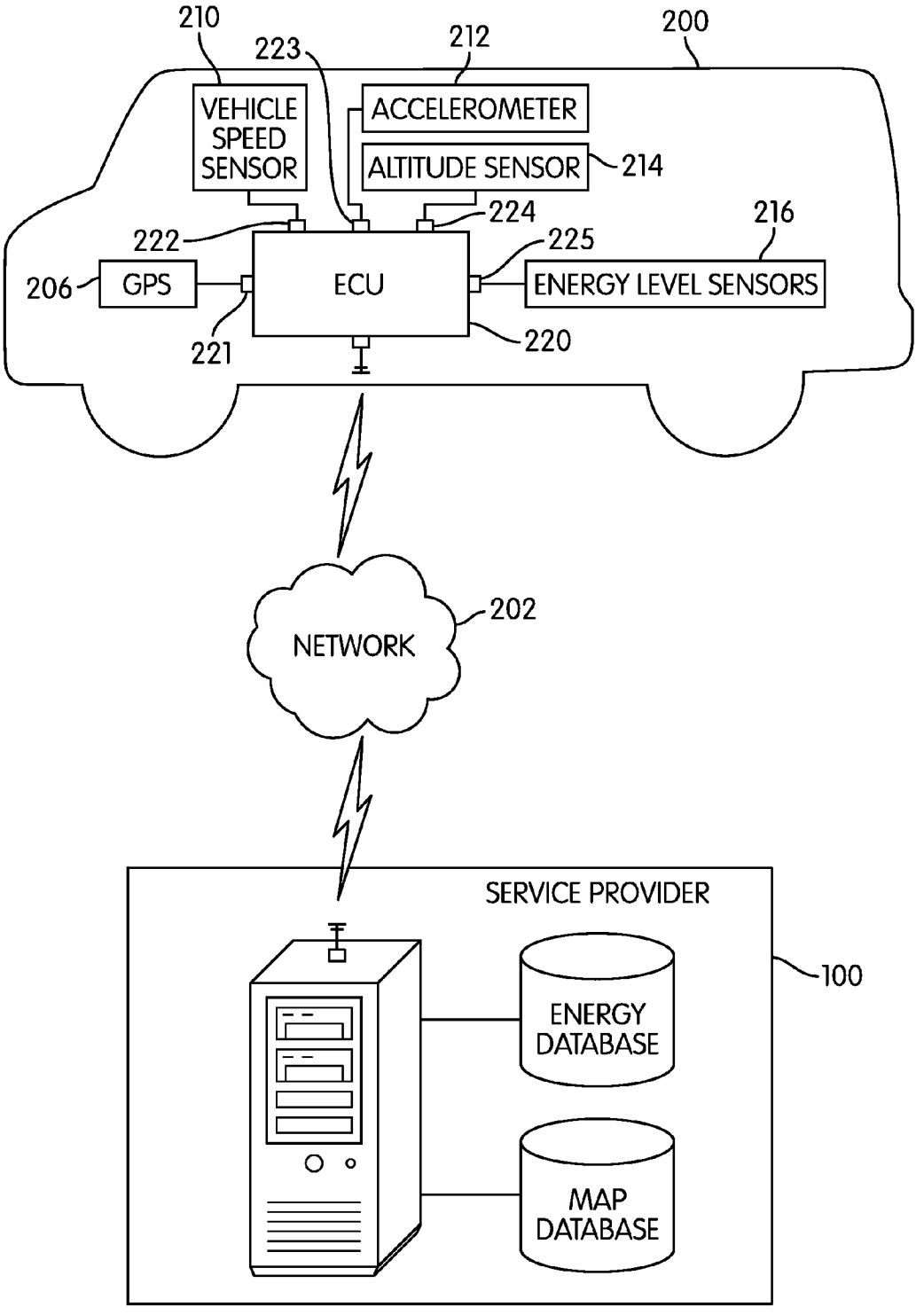

210
223
212
200
VEHICLE SPEED SENSOR
ACCELEROMETER
ALTITUDE SENSOR
214
224
216
222
225
206
GPS
ECU
ENERGY LEVEL SENSORS
221
220
NETWORK
202
SERVICE PROVIDER
100
ENERGY DATABASE
MAP DATABASE

FIG. 2

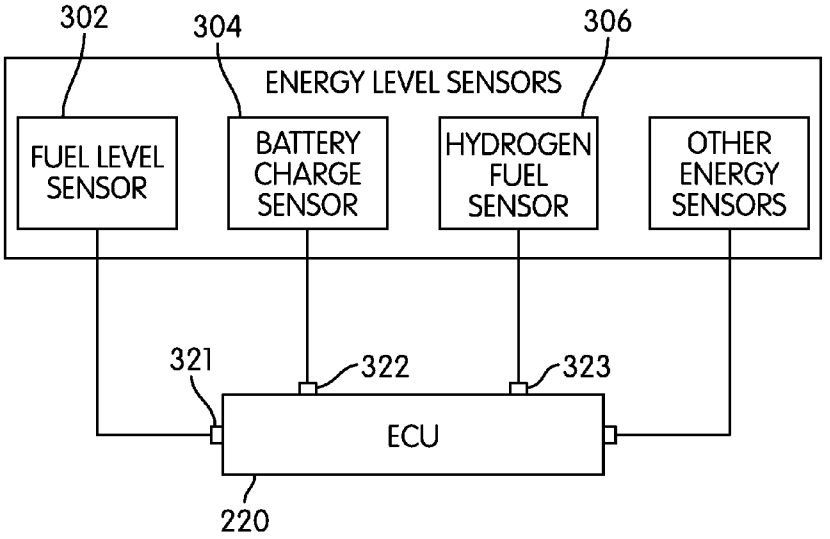

302
304
306
ENERGY LEVEL SENSORS
FUEL LEVEL SENSOR
BATTERY CHARGE SENSOR
HYDROGEN FUEL SENSOR
OTHER ENERGY SENSORS
321
322
323
ECU
220

FIG. 3

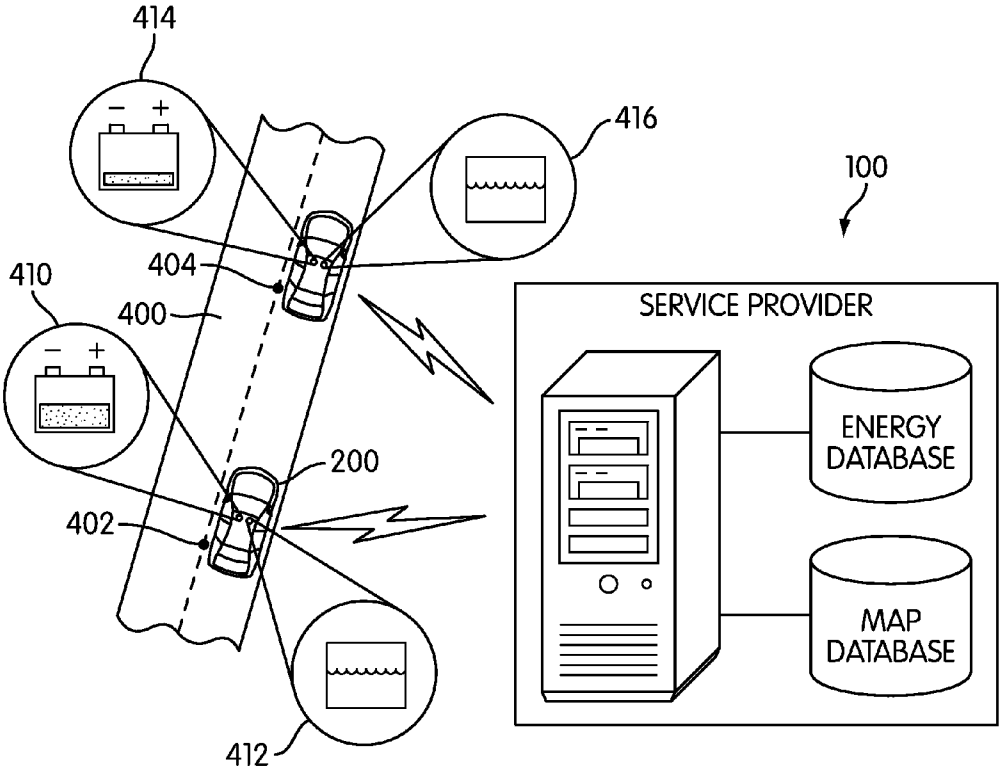

414
416
100
410
404
400
SERVICE PROVIDER
ENERGY DATABASE
MAP DATABASE
200
402
412

FIG. 4

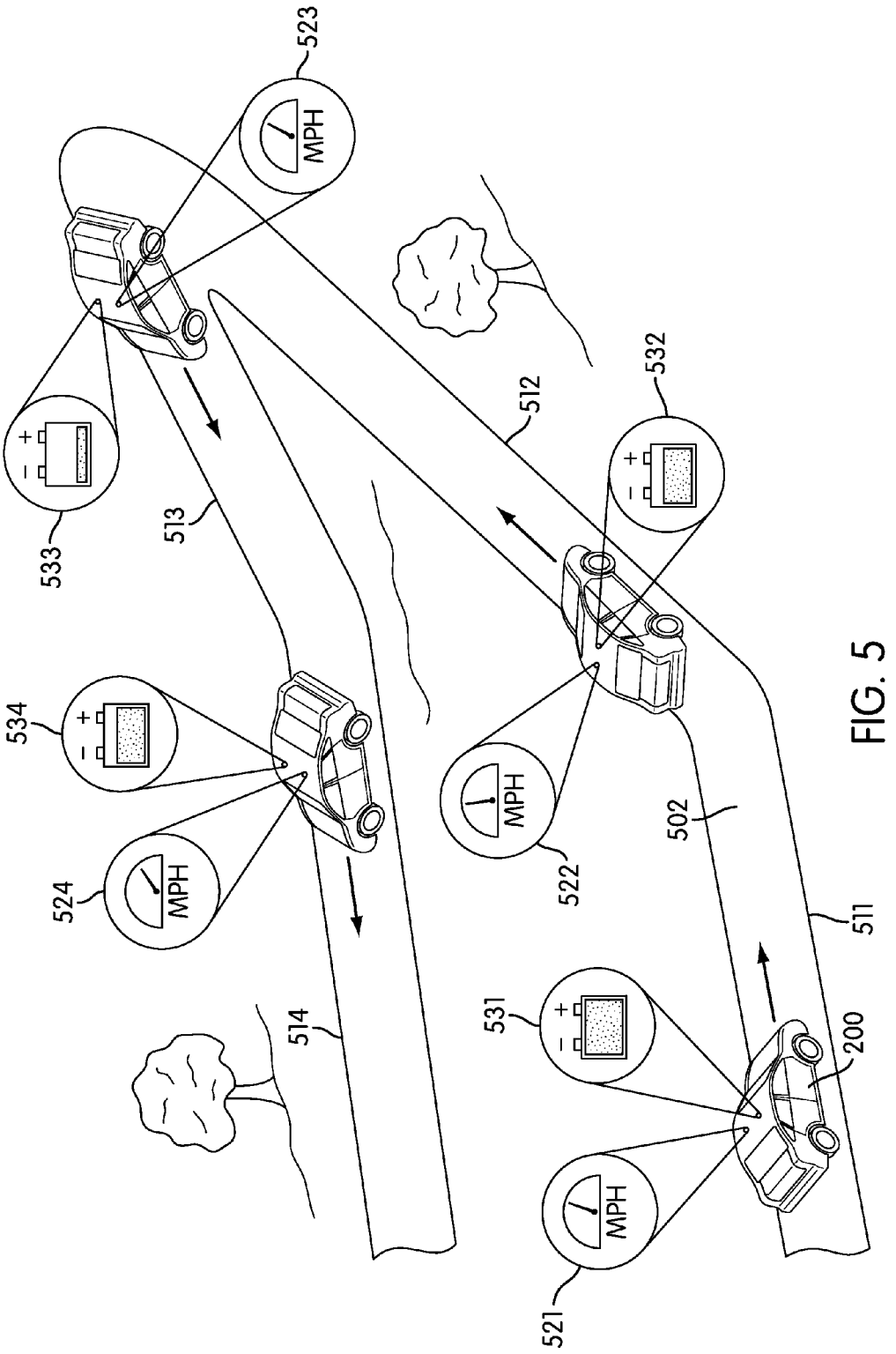

523
MPH
533
513
534
524
MPH
514
512
532
522
MPH
502
511
531
200
521
MPH

FIG. 5

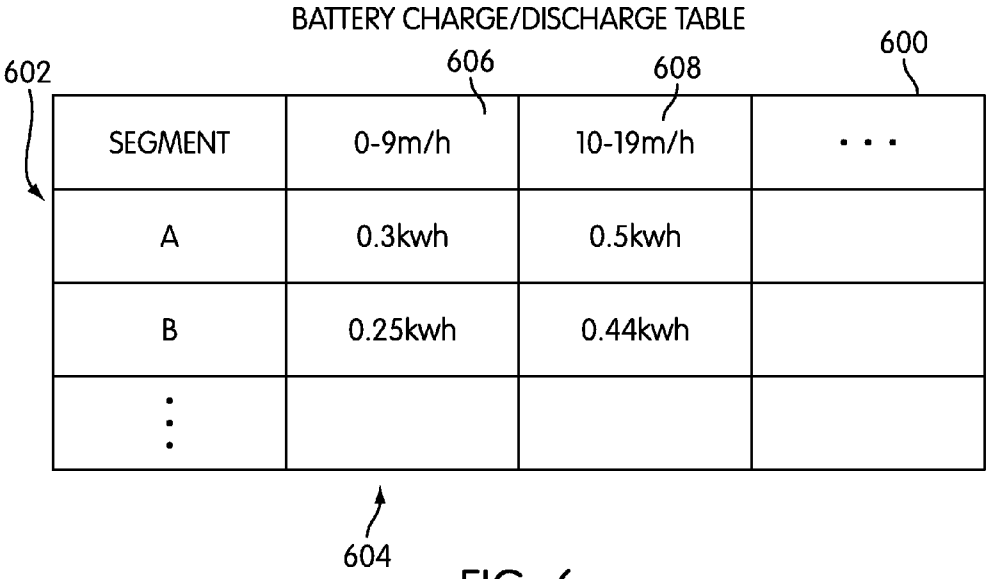

BATTERY CHARGE/DISCHARGE TABLE
600
602
606
608
SEGMENT
0-9m/h
10-19m/h
A
0.3kwh
0.5kwh
B
0.25kwh
0.44kwh
604

FIG. 6

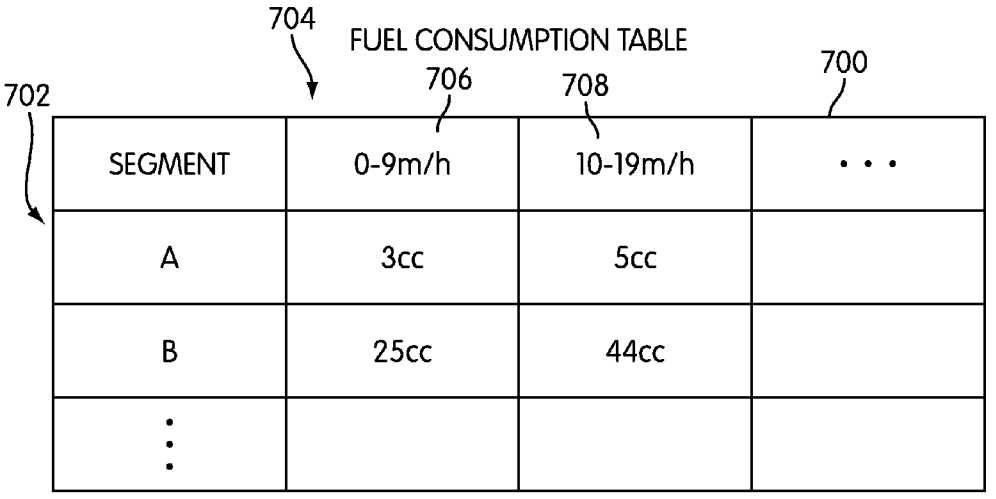

704
FUEL CONSUMPTION TABLE
700
702
706
708
SEGMENT
0-9m/h
10-19m/h
A
3cc
5cc
B
25cc
44cc

FIG. 7

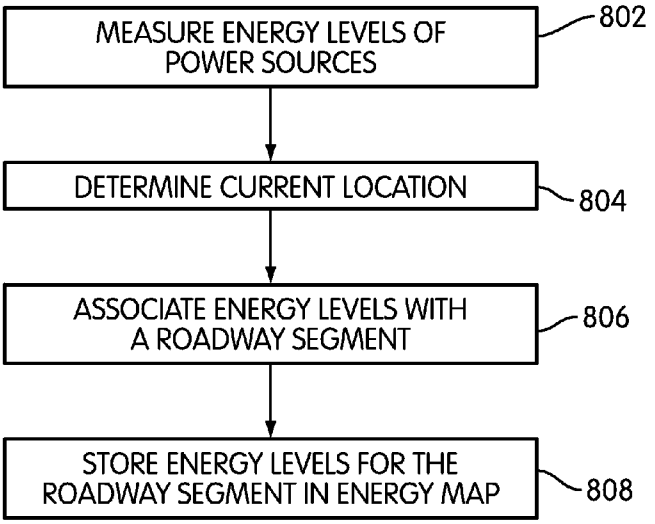

MEASURE ENERGY LEVELS OF POWER SOURCES
802
DETERMINE CURRENT LOCATION
804
ASSOCIATE ENERGY LEVELS WITH A ROADWAY SEGMENT
806
STORE ENERGY LEVELS FOR THE ROADWAY SEGMENT IN ENERGY MAP
808

FIG. 8

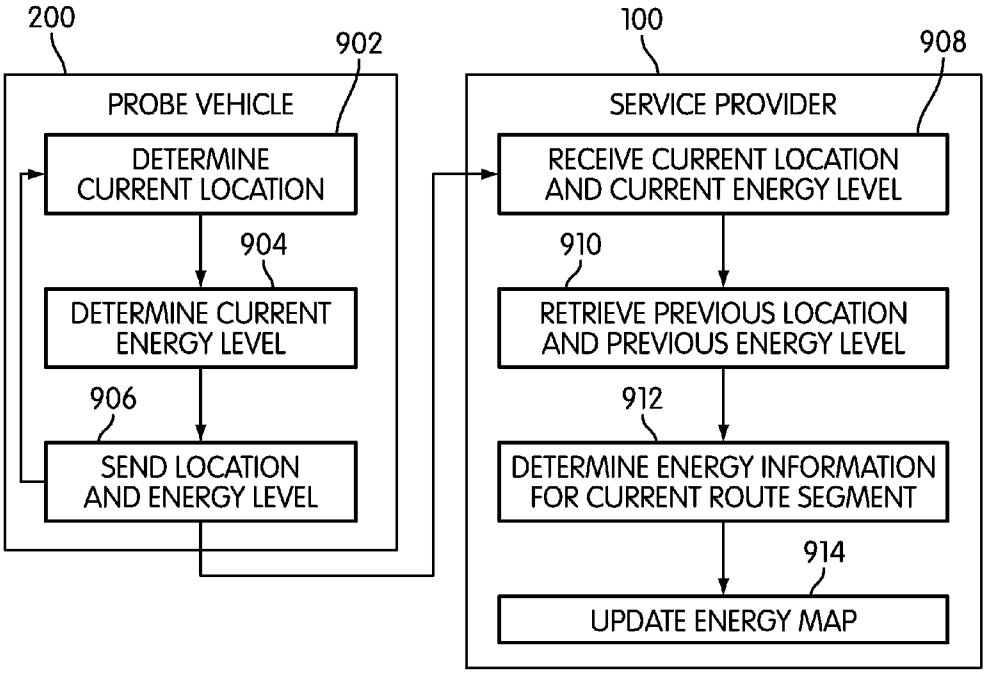

200
902
PROBE VEHICLE
DETERMINE CURRENT LOCATION
904
DETERMINE CURRENT ENERGY LEVEL
906
SEND LOCATION AND ENERGY LEVEL
100
908
SERVICE PROVIDER
RECEIVE CURRENT LOCATION AND CURRENT ENERGY LEVEL
910
RETRIEVE PREVIOUS LOCATION AND PREVIOUS ENERGY LEVEL
912
DETERMINE ENERGY INFORMATION FOR CURRENT ROUTE SEGMENT
914
UPDATE ENERGY MAP

FIG. 9

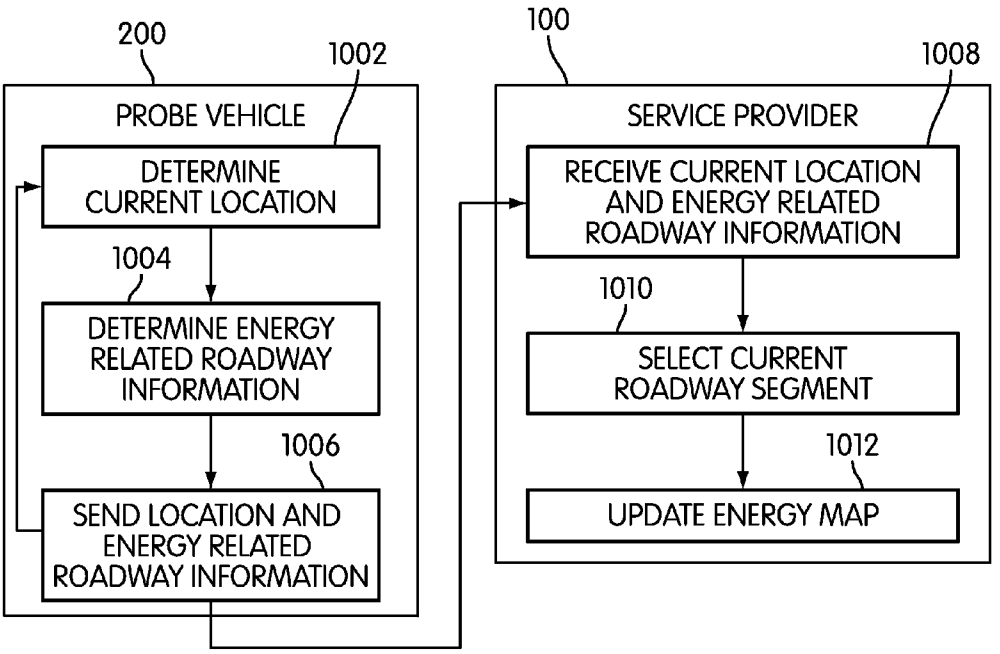

200
1002
PROBE VEHICLE
DETERMINE CURRENT LOCATION
1004
DETERMINE ENERGY RELATED ROADWAY INFORMATION
1006
SEND LOCATION AND ENERGY RELATED ROADWAY INFORMATION
100
1008
SERVICE PROVIDER
RECEIVE CURRENT LOCATION AND ENERGY RELATED ROADWAY INFORMATION
1010
SELECT CURRENT ROADWAY SEGMENT
1012
UPDATE ENERGY MAP

FIG. 10

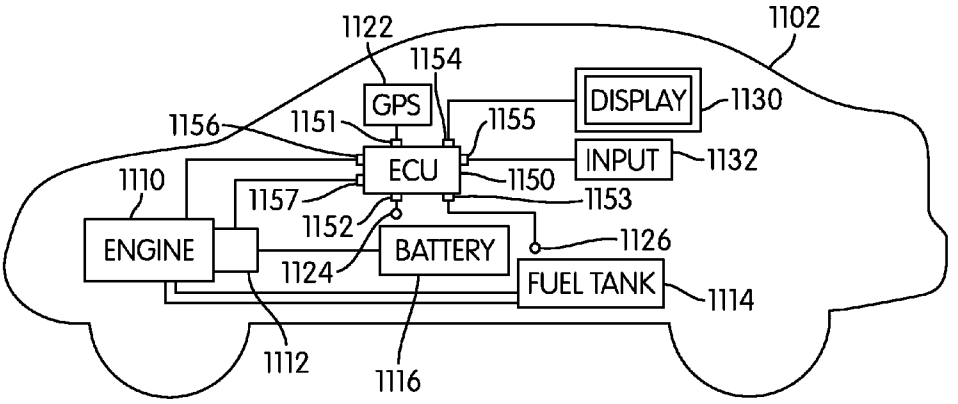

1102
1122
1154
GPS
DISPLAY
1130
1156
1151
1155
ECU
INPUT
1132
1110
1150
1157
1153
1152
1126
ENGINE
BATTERY
1124
FUEL TANK
1114
1112
1116

FIG. 11

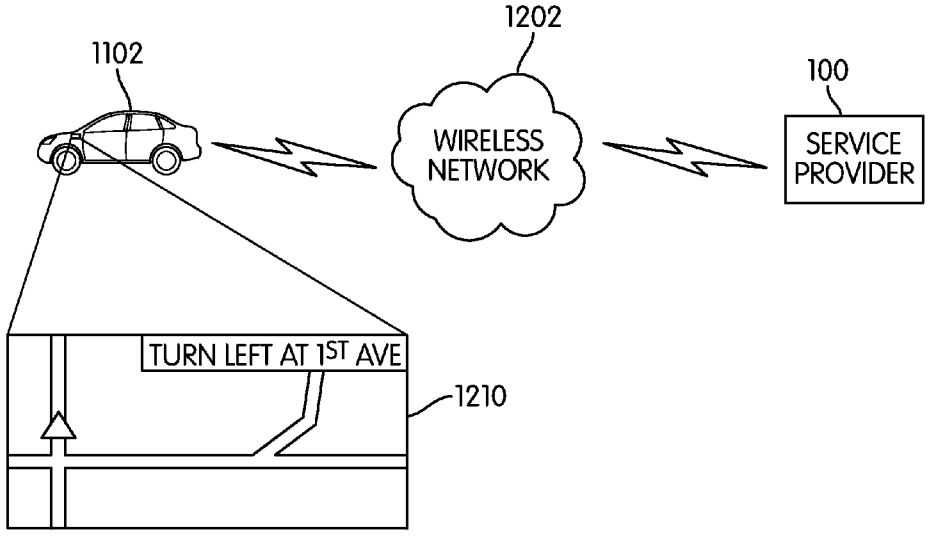

1202
1102
100
WIRELESS NETWORK
SERVICE PROVIDER
TURN LEFT AT 1ST AVE
1210

FIG. 12

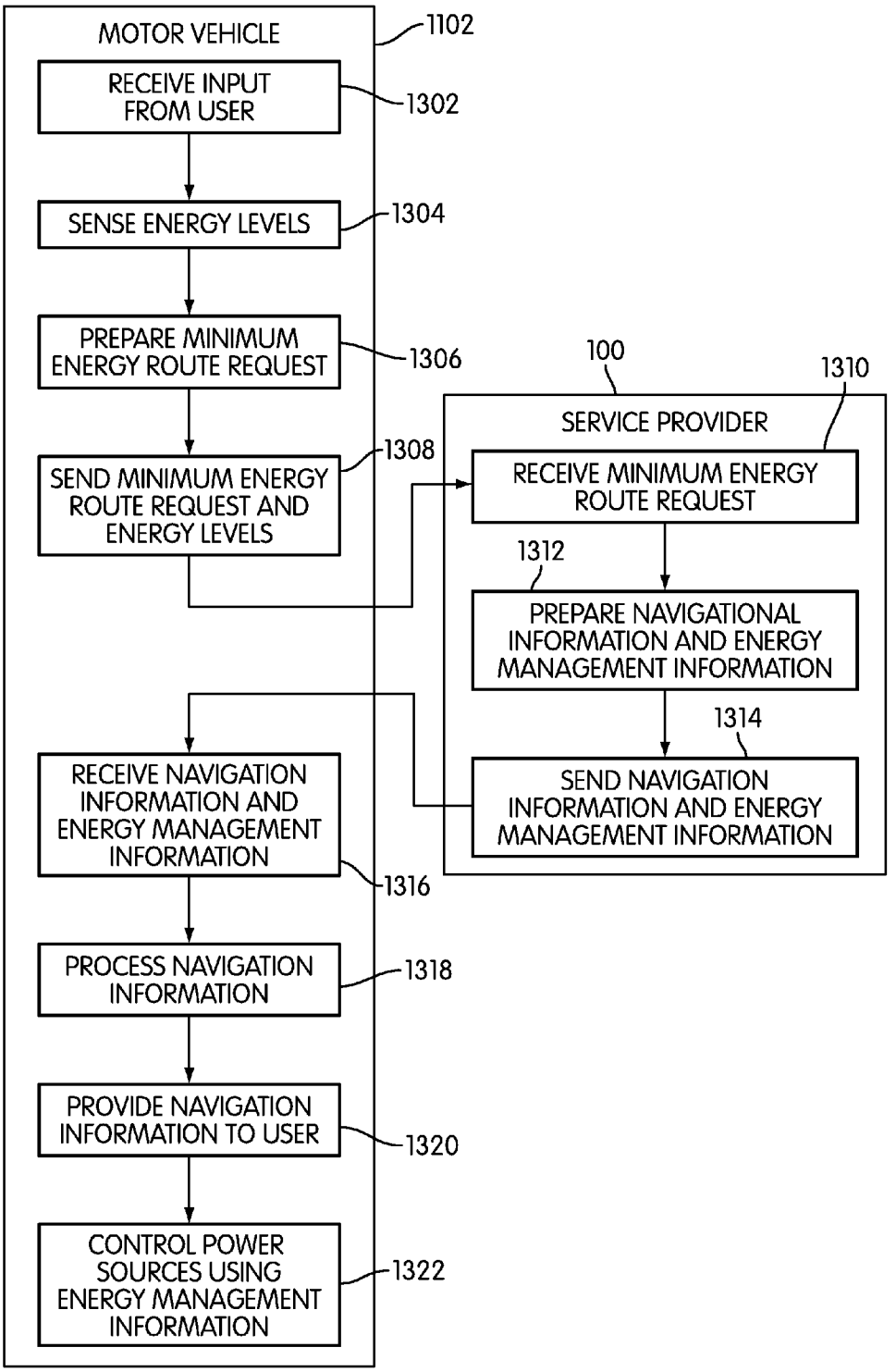

MOTOR VEHICLE
1102
RECEIVE INPUT FROM USER
1302
SENSE ENERGY LEVELS
1304
PREPARE MINIMUM ENERGY ROUTE REQUEST
1306
SEND MINIMUM ENERGY ROUTE REQUEST AND ENERGY LEVELS
1308
RECEIVE NAVIGATION INFORMATION AND ENERGY MANAGEMENT INFORMATION
1316
PROCESS NAVIGATION INFORMATION
1318
PROVIDE NAVIGATION INFORMATION TO USER
1320
CONTROL POWER SOURCES USING ENERGY MANAGEMENT INFORMATION
1322
100
SERVICE PROVIDER
1310
RECEIVE MINIMUM ENERGY ROUTE REQUEST
1312
PREPARE NAVIGATIONAL INFORMATION AND ENERGY MANAGEMENT INFORMATION
1314
SEND NAVIGATION INFORMATION AND ENERGY MANAGEMENT INFORMATION

FIG. 13

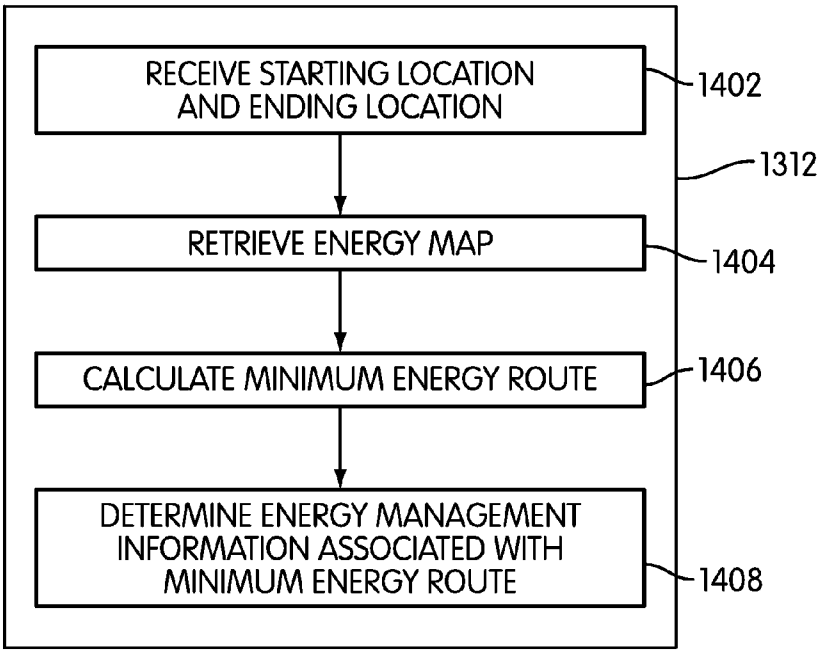

RECEIVE STARTING LOCATION AND ENDING LOCATION
1402
1312
RETRIEVE ENERGY MAP
1404
CALCULATE MINIMUM ENERGY ROUTE
1406
DETERMINE ENERGY MANAGEMENT INFORMATION ASSOCIATED WITH MINIMUM ENERGY ROUTE
1408

FIG. 14

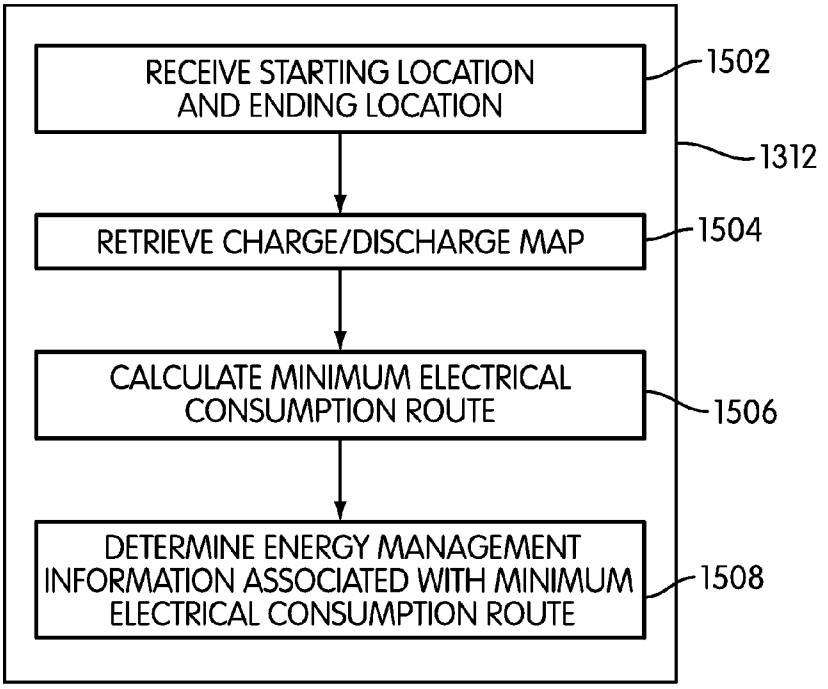

RECEIVE STARTING LOCATION AND ENDING LOCATION
1502
1312
RETRIEVE CHARGE/DISCHARGE MAP
1504
CALCULATE MINIMUM ELECTRICAL CONSUMPTION ROUTE
1506
DETERMINE ENERGY MANAGEMENT INFORMATION ASSOCIATED WITH MINIMUM ELECTRICAL CONSUMPTION ROUTE
1508

FIG. 15

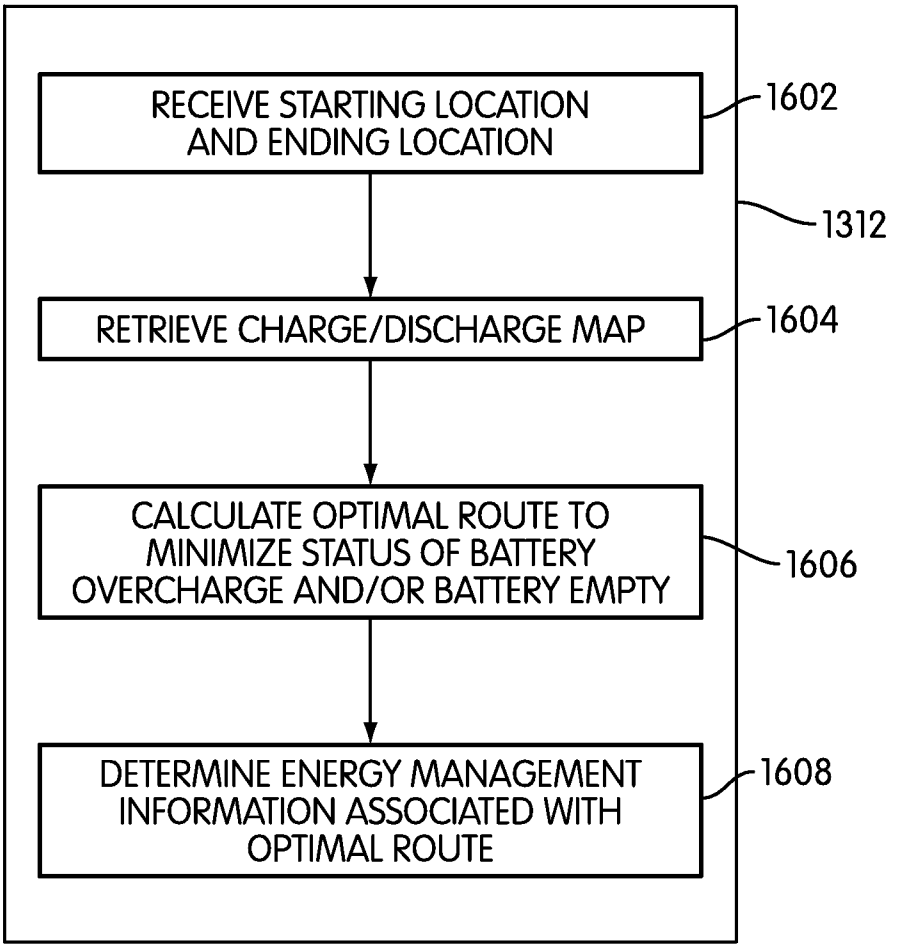

RECEIVE STARTING LOCATION AND ENDING LOCATION
1602
1312
RETRIEVE CHARGE/DISCHARGE MAP
1604
CALCULATE OPTIMAL ROUTE TO MINIMIZE STATUS OF BATTERY OVERCHARGE AND/OR BATTERY EMPTY
1606
DETERMINE ENERGY MANAGEMENT INFORMATION ASSOCIATED WITH OPTIMAL ROUTE
1608

FIG. 16

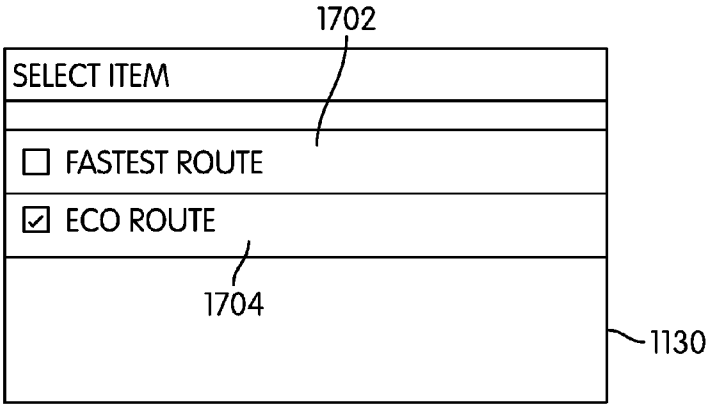

1702
SELECT ITEM
FASTEST ROUTE
ECO ROUTE
1704
1130

FIG. 17

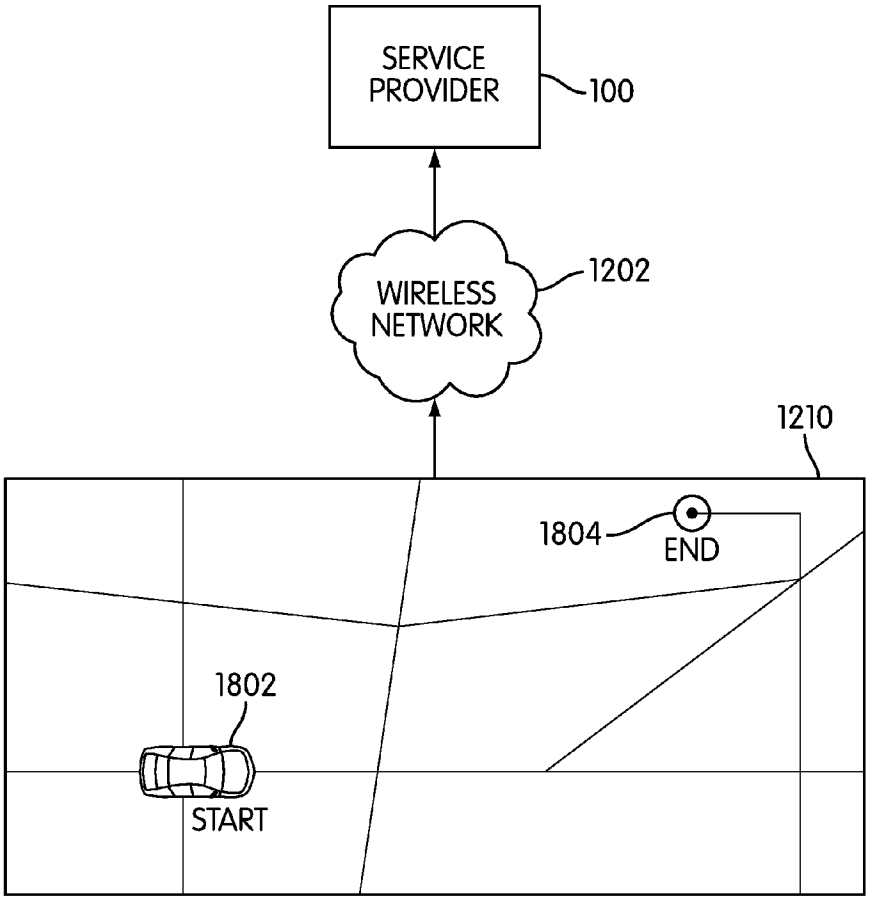

SERVICE PROVIDER
100
WIRELESS NETWORK
1202
1210
1804
END
1802
START

FIG. 18

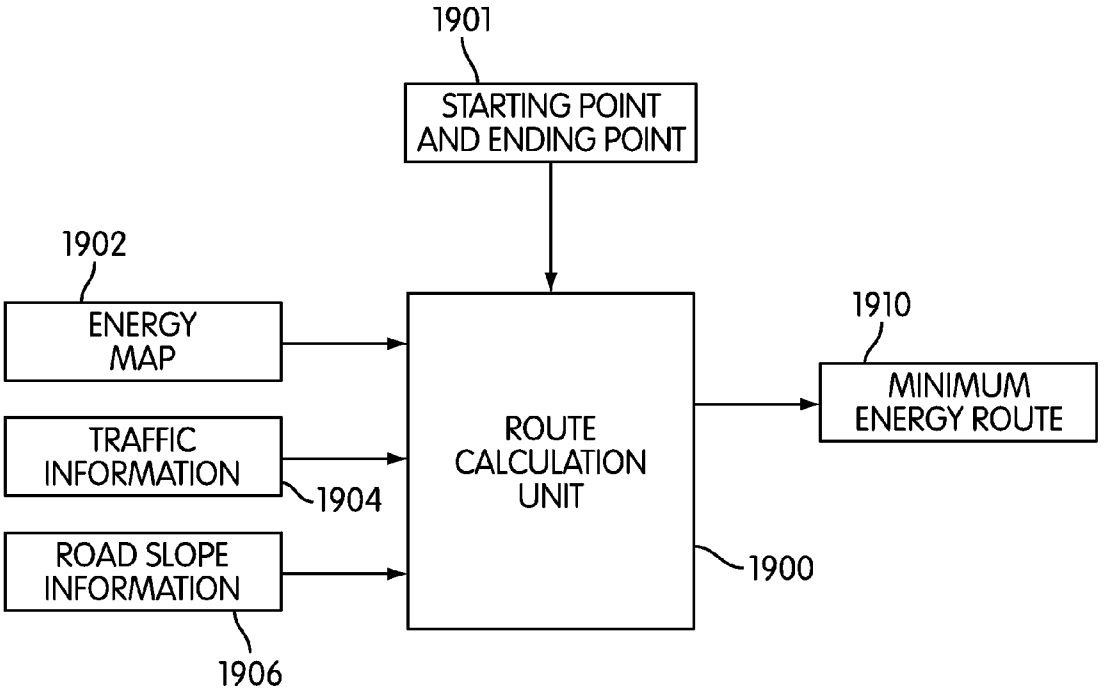

1901
STARTING POINT AND ENDING POINT
1902
ENERGY MAP
TRAFFIC INFORMATION
1904
ROAD SLOPE INFORMATION
1906
ROUTE CALCULATION UNIT
1900
1910
MINIMUM ENERGY ROUTE

FIG. 19

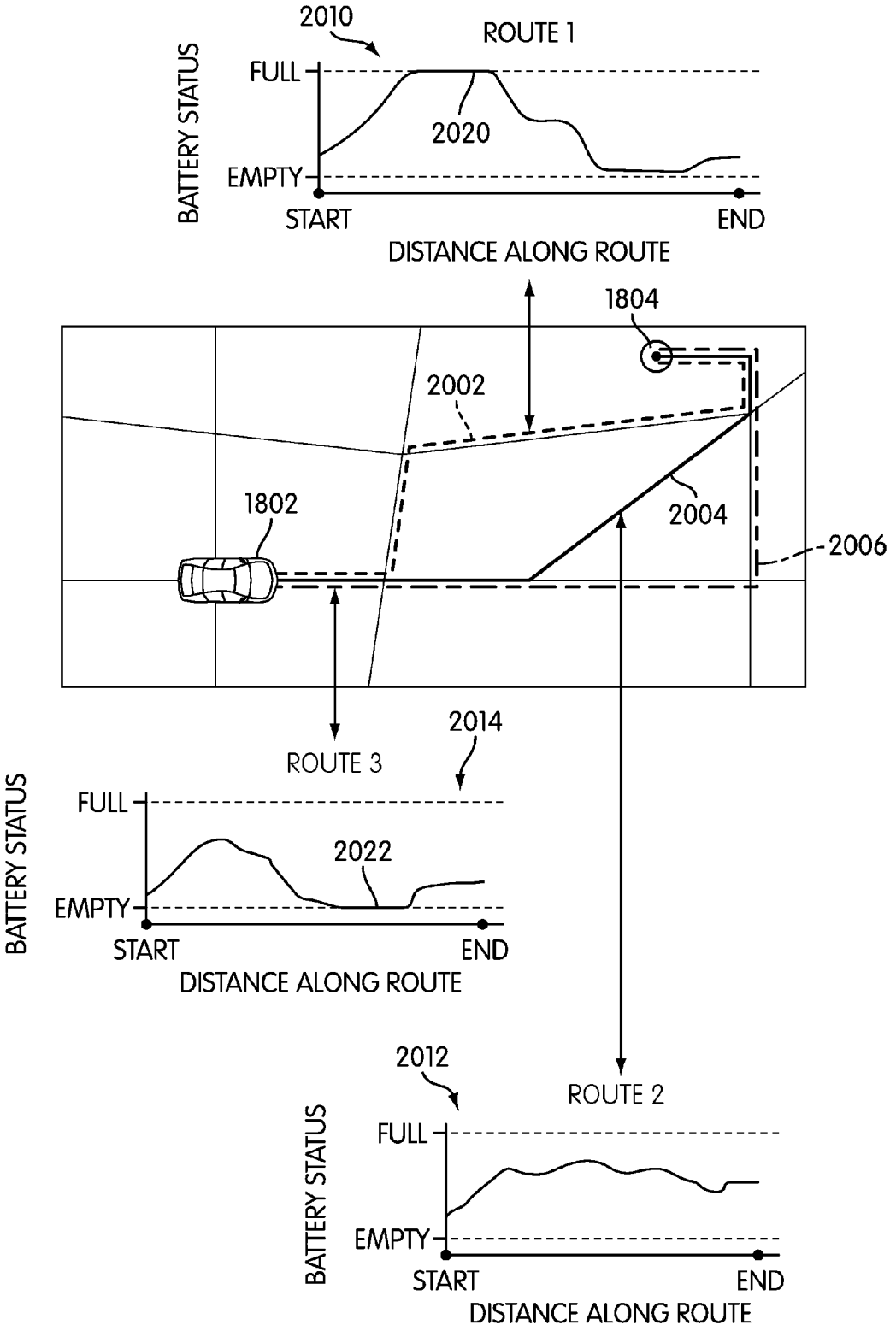

2010
ROUTE 1
FULL
EMPTY
BATTERY STATUS
2020
START
END
DISTANCE ALONG ROUTE
1804
2002
1802
2004
2006
2014
ROUTE 3
FULL
EMPTY
BATTERY STATUS
2022
START
END
DISTANCE ALONG ROUTE
2012
ROUTE 2
FULL
EMPTY
BATTERY STATUS
START
END
DISTANCE ALONG ROUTE

FIG. 20

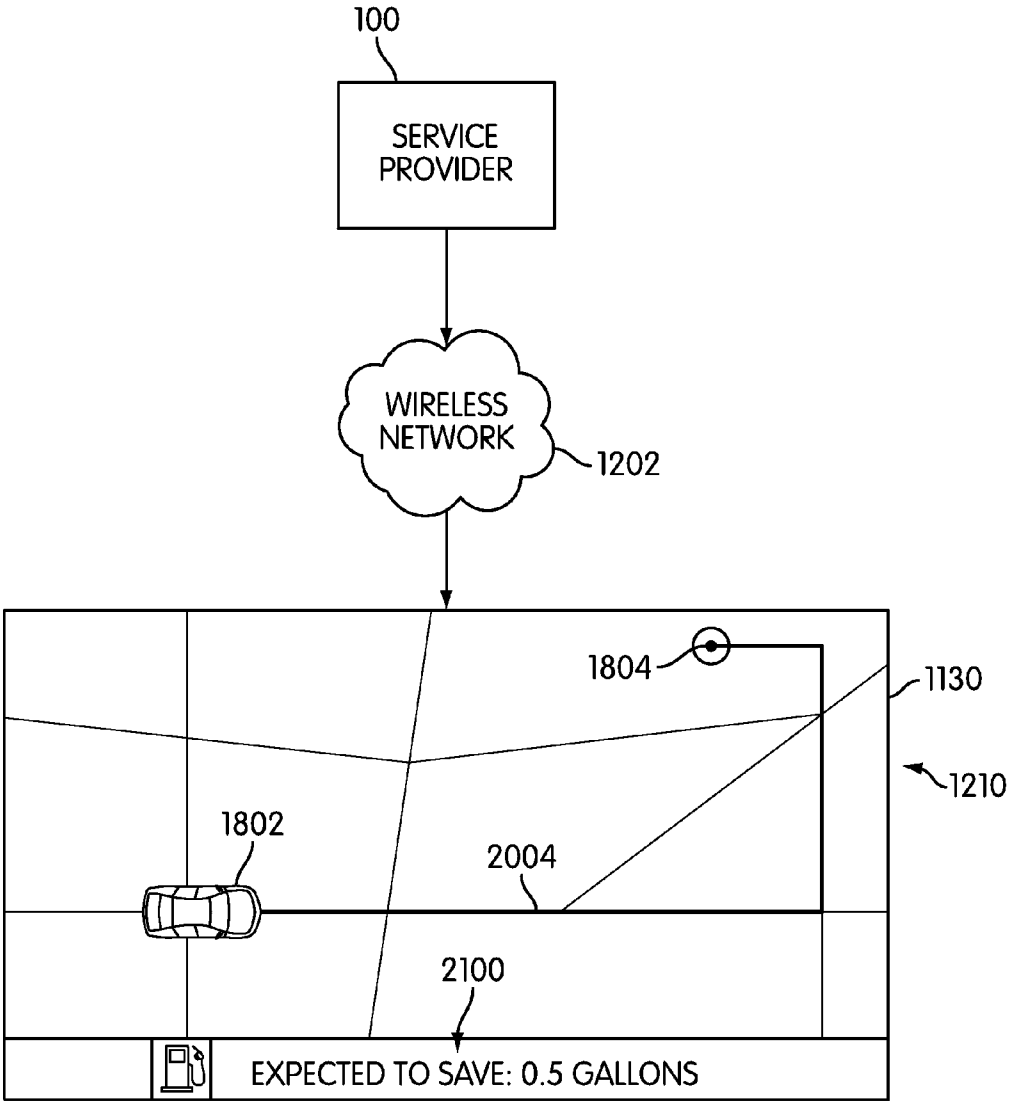

100
SERVICE PROVIDER
WIRELESS NETWORK
1202
1804
1130
1210
1802
2004
2100
EXPECTED TO SAVE: 0.5 GALLONS

FIG. 21

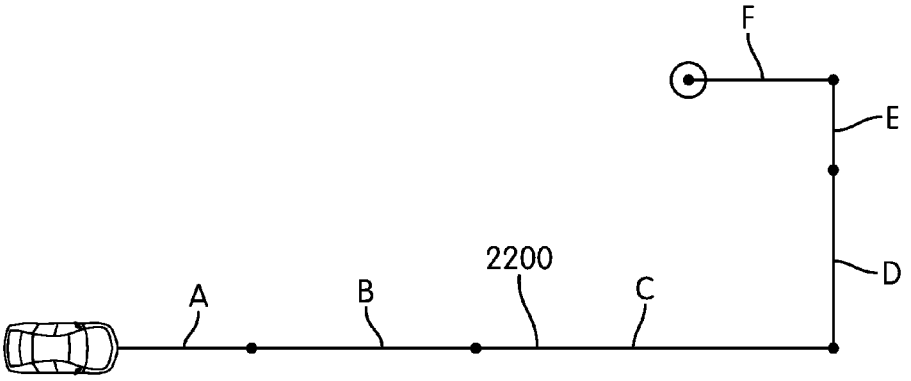


FIG. 22

2300

2304

2302

ENERGY MANAGEMENT INFORMATION TABLE

SEGMENT	ELECTRIC MOTOR CHARGE/DISCHARGE	SLOPE	CONGESTION	FUEL USE
A	+1 UNIT	NONE	NONE	-1 UNIT
B	+1 UNIT	NONE	NONE	-1 UNIT
C	+5 UNITS	DOWN	LOW	-2 UNITS
D	-2 UNITS	UP	MEDIUM	-1 UNIT
E	-1 UNIT	UP	NONE	-1 UNIT
F	+1 UNIT	NONE	NONE	-1 UNIT

2306 2308 2310

FIG. 23

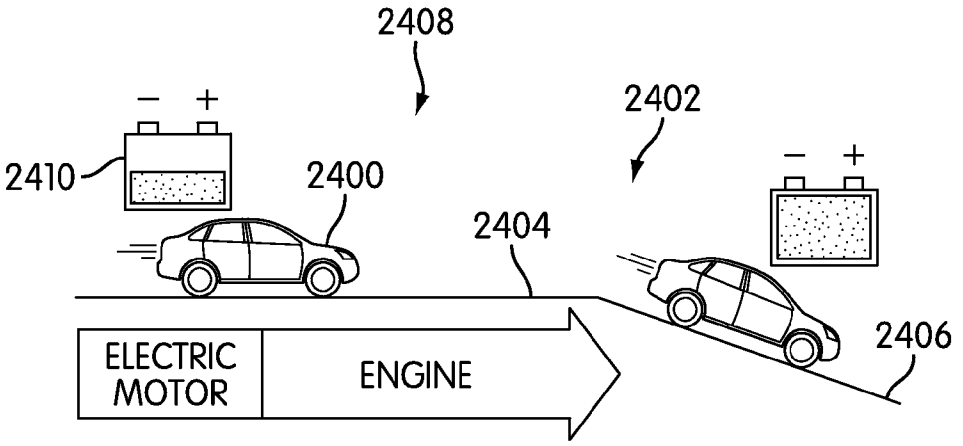

2408
2402
2410
2400
2404
2406
ELECTRIC MOTOR
ENGINE

FIG. 24

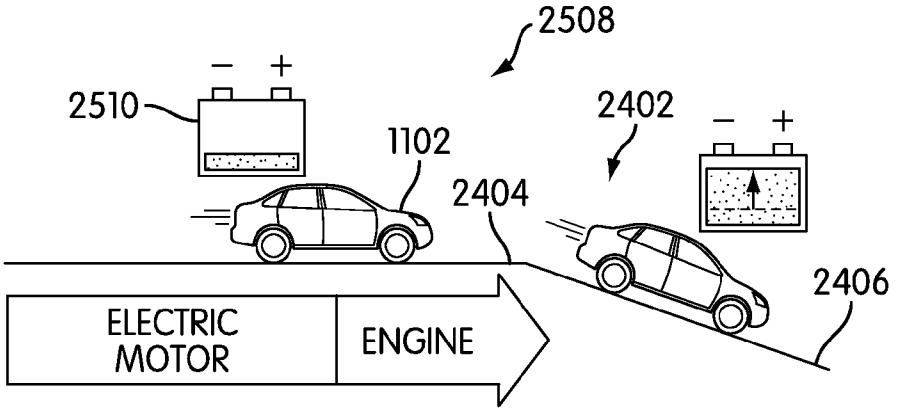

2508
2510
2402
1102
2404
2406
ELECTRIC MOTOR
ENGINE

FIG. 25

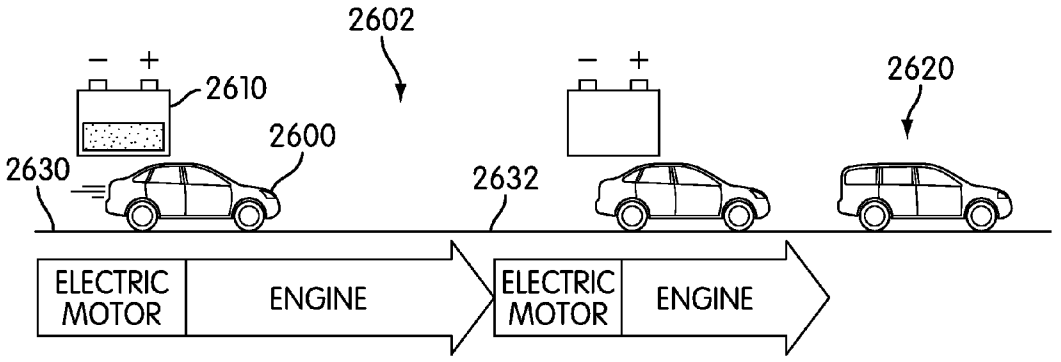

2602
2610
2600
2620
2630
2632
ELECTRIC MOTOR
ENGINE
ELECTRIC MOTOR
ENGINE

FIG. 26

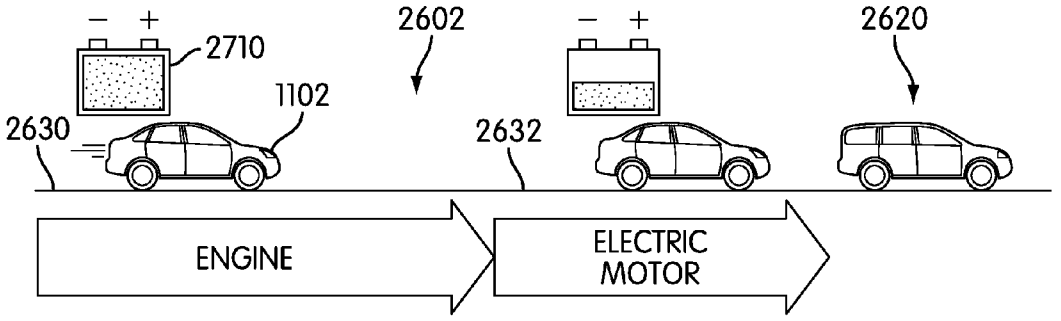

2602
2710
1102
2620
2630
2632
ENGINE
ELECTRIC MOTOR

FIG. 27

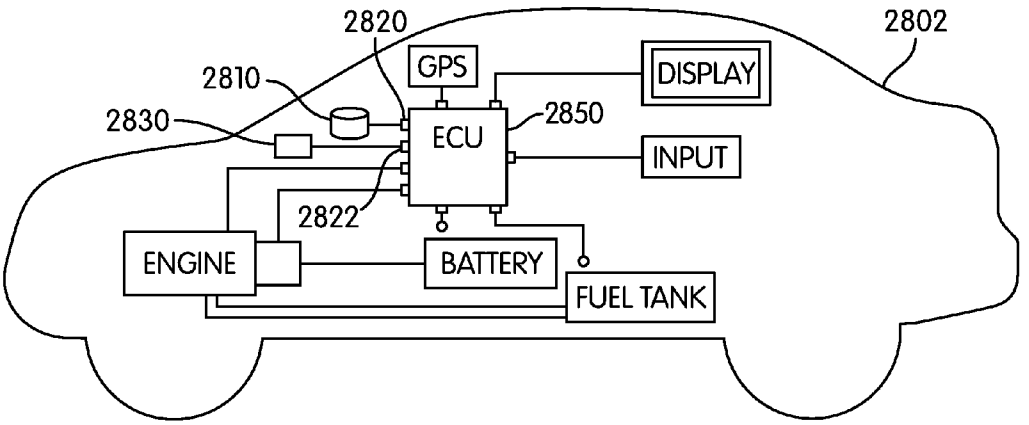

2820
2802
2810
GPS
DISPLAY
2830
ECU
2850
INPUT
2822
ENGINE
BATTERY
FUEL TANK

FIG. 28

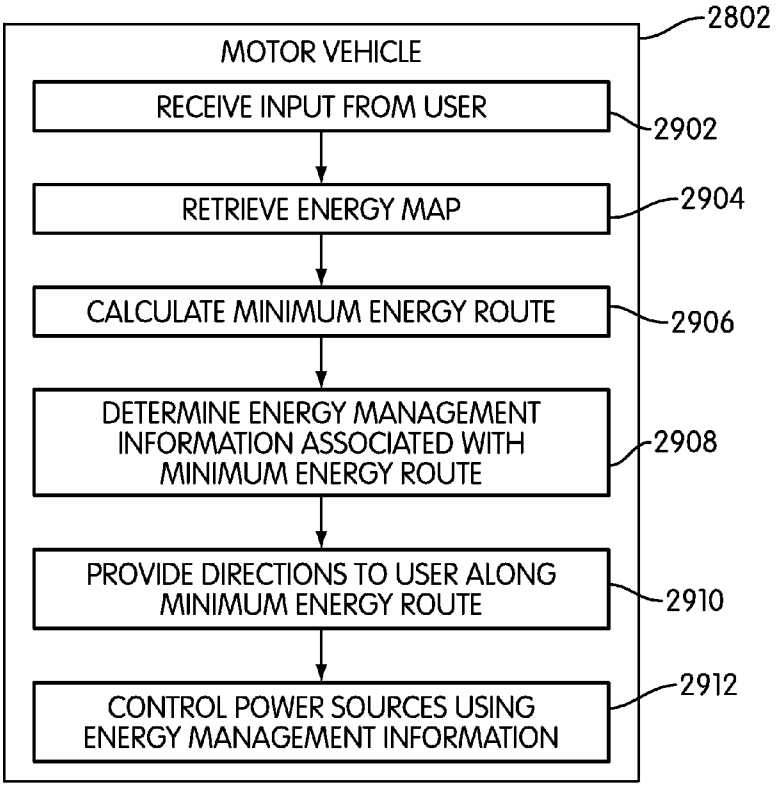

2802
MOTOR VEHICLE
RECEIVE INPUT FROM USER
2902
RETRIEVE ENERGY MAP
2904
CALCULATE MINIMUM ENERGY ROUTE
2906
DETERMINE ENERGY MANAGEMENT INFORMATION ASSOCIATED WITH MINIMUM ENERGY ROUTE
2908
PROVIDE DIRECTIONS TO USER ALONG MINIMUM ENERGY ROUTE
2910
CONTROL POWER SOURCES USING ENERGY MANAGEMENT INFORMATION
2912

FIG. 29

ENERGY MAPS AND METHOD OF MAKING

BACKGROUND

The embodiments relate generally to a motor vehicle, and in particular to energy maps for use with a motor vehicle and a method of making the energy maps.

Modern vehicles use navigation systems to determine fastest routes for traveling between a starting point and a destination. These systems use mapping information to determine routes that minimize distance or travel time. However, there is a growing need for systems that are capable of determining routes that are optimized to reduce emissions and save energy.

SUMMARY

The term "motor vehicle" as used throughout the specification and claims refers to any moving vehicle that is capable of carrying one or more human occupants and is powered by any form of energy. The term "motor vehicle" includes, but is not limited to: cars, trucks, vans, minivans, SUVs, motorcycles, scooters, boats, personal watercraft, and aircraft.

In some cases, the motor vehicle includes one or more engines. The term "engine" as used throughout the specification and claims refers to any device or machine that is capable of converting energy. In some cases, potential energy is converted to kinetic energy. For example, energy conversion can include a situation where the chemical potential energy of a fuel or fuel cell is converted into rotational kinetic energy or where electrical potential energy is converted into rotational kinetic energy. Engines can also include provisions for converting kinetic energy into potential energy. For example, some engines include regenerative braking systems where kinetic energy from a drivetrain is converted into potential energy. Engines can also include devices that convert solar or nuclear energy into another form of energy. Some examples of engines include, but are not limited to: internal combustion engines, electric motors, solar energy converters, turbines, nuclear power plants, and hybrid systems that combine two or more different types of energy conversion processes.

In one aspect, a method of operating a motor vehicle may include several steps. The method may begin by determining a first location of the motor vehicle, where the first location corresponds to a first portion of a roadway segment. In another step, the method may measure a first state of charge of a battery at the first location. In another step, the method may determine a second location of the motor vehicle, where the second location corresponds to a second portion of the roadway segment that is different from the first portion. In another step, the method may measure a second state of charge of a battery at the second location. In another step, the method may submit the first state of charge value and the first location to a service provider, and submit the second state of charge value and the second location to the service provider.

In another aspect, a method of making an energy map, the method may include the following steps. The method may begin by receiving information related to a current state of charge of a battery in a motor vehicle. In another step, the may receive a current location of the motor vehicle. In another step, the method may retrieve a previous state of charge associated with the motor vehicle. In another step, the method may retrieve a previous location of the motor vehicle, the previous location being associated with the previous state of charge. In another step, the method may determine a roadway segment extending between the previous location and the current location. In another step, the method may determine a state of charge difference between the previous state of charge and the current state of charge. In another step, the method may associate the state of charge difference with the roadway segment in the energy map.

In another aspect, a method of operating a motor vehicle may include the following steps. The method may begin by determining a location of the motor vehicle. In another step, the method may measure a first energy level of a first power source. In another step, the method may measure a second energy level of a second power source. In another step, the method may submit the first energy level, the second energy level and the location to a service provider.

In another aspect, a method of making an energy map may include the following steps. The method may begin by receiving information related to a first energy level of a first power source. In another step, the method may receive information related to a second energy level of a second power source. In another step, the method may receive information related to a current location. In another step, the method may retrieve a first previous energy level associated with the first power source. In another step, the method may retrieve a second previous energy level associated with the second power source. In another step, the method may retrieve a previous location. In another step, the method may determine a roadway segment extending between the previous location and the current location. In another step, the method may determine a first energy level difference between the first previous energy level and the first energy level. In another step, the method may determine a second energy level difference between the second previous energy level and the second energy level. In another step, the method may associate the first energy level difference and the second energy level difference with the roadway segment to make the energy map.

In another aspect, a method of making an energy map may include the following steps. The method may begin by receiving information related to a current roadway segment. In another step, the method may receive energy related roadway information about the current roadway segment. In another step, the method may associate the energy related roadway information with the current roadway segment in the energy map.

In another aspect, a method of making an energy map may include the following steps. The method may begin by receiving information related to a roadway segment. In another step, the method may receive operating conditions associated with a motor vehicle. In another step, the method may determine a first vehicle speed associated with the roadway segment. In another step, the method may determine a first state of charge difference associated with traveling on the roadway segment at the first vehicle speed. In another step, the method may determine a second vehicle speed associated with roadway segment, where the second vehicle speed is different from the first vehicle speed. In another step, the method may determine a second state of charge difference associated with traveling on the roadway segment at the second vehicle speed. In another step, the method may store the first state of charge difference in a first speed range associated with the roadway segment and store the second state of charge difference in a second speed range associated with the roadway segment. The first speed range may be different than the second speed range, the first vehicle speed may be within the first speed range, and the second vehicle speed may be within the second speed range.

Other systems, methods, features and advantages of the exemplary embodiments will be, or will become, apparent to one of ordinary skill in the art upon examination of the following figures and detailed description. It is intended that all such additional systems, methods, features and advantages be

included within this description and this summary, be within the scope and protected by the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The exemplary embodiments can be better understood with reference to the following drawings and description. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the exemplary embodiments. Moreover, in the figures, like reference numerals designate corresponding parts throughout the different views.

FIG. **1** is a schematic view of an embodiment of a service provider including an energy map;

FIG. **2** is a schematic view of an embodiment of a probe vehicle in communication with a service provider;

FIG. **3** is a schematic view of an embodiment of a set of energy level sensors for a motor vehicle;

FIG. **4** is a schematic view of an embodiment of a probe vehicle making energy level measurements;

FIG. **5** is a schematic view of an embodiment of a probe vehicle making energy level measurements and vehicle speed measurements;

FIG. **6** is a schematic view of an embodiment of a battery charge/discharge table;

FIG. **7** is a schematic view of an embodiment of a fuel consumption table;

FIG. **8** is an embodiment of a process for making an energy map;

FIG. **9** is an embodiment of a detailed process for making an energy map;

FIG. **10** is another embodiment of a detailed process for making an energy map;

FIG. **11** is a schematic view of an embodiment of a motor vehicle configured to provide navigational information to a user;

FIG. **12** is a schematic view of an embodiment of a motor vehicle in communication with a service provider through a wireless network;

FIG. **13** is an embodiment of a process of obtaining a navigation information and energy management information for a motor vehicle;

FIG. **14** is an embodiment of a process of preparing navigation information and energy management information;

FIG. **15** is another embodiment of a process of preparing navigation information and energy management information;

FIG. **16** is another embodiment of a process of preparing navigation information and energy management information;

FIG. **17** is a schematic view of an embodiment of a display screen for a navigation system;

FIG. **18** is a schematic view of an embodiment of a process of submitting a navigation request;

FIG. **19** is a schematic view of an embodiment of a method of determining a minimum energy route;

FIG. **20** is a schematic view of an embodiment of a process of determining a minimum energy route;

FIG. **21** is a schematic view of an embodiment of a process of receiving navigation information and energy management information;

FIG. **22** is a schematic view of an embodiment of a navigation route configured to optimize energy consumption;

FIG. **23** is a schematic view of an embodiment of a table of energy management information;

FIG. **24** is a schematic view of an embodiment of a method of controlling a motor vehicle on a predetermined route;

FIG. **25** is a schematic view of an embodiment of a method of controlling a motor vehicle on a predetermined route;

FIG. **26** is a schematic view of an embodiment of a method of controlling a motor vehicle on a predetermined route;

FIG. **27** is a schematic view of an embodiment of a method of controlling a motor vehicle on a predetermined route;

FIG. **28** is a schematic view of an embodiment of a motor vehicle including an onboard map database; and

FIG. **29** is an embodiment of a process of determining navigation information and energy management information for a motor vehicle.

DETAILED DESCRIPTION

FIG. **1** illustrates a schematic diagram of an embodiment of a service provider **100** that is configured to communicate with a motor vehicle. In some embodiments, service provider **100** can include a computer system **102** and databases **104** in communication with computer system **102**. The term "computer system" refers to the computing resources of a single computer, a portion of the computing resources of a single computer, and/or two or more computers in communication with one another, also any of these resources can be operated by one or more human users. In one embodiment, computer system **102** includes a server.

Computer system **102** may communicate with databases **104**. Databases **104** can include any kind of storage device, including but not limited to: magnetic, optical, magneto-optical, and/or memory, including volatile memory and non-volatile memory. In some embodiments, databases **104** may be integral with computer system **102**. In other embodiments, databases **104** are separate from computer system **102** and communicate with computer system **102**.

Databases **104** can comprise any number of databases. In some cases, databases **104** can include map database **106**. In some embodiments, map database **106** may be used to store navigation information. The term "navigation information" refers to any information that can be used to assist in determining a location or providing directions to a location. Some examples of navigation information include street addresses, street names, street or address numbers, apartment or suite numbers, intersection information, points of interest, parks, any political or geographical subdivision including town, township, province, prefecture, city, state, district, ZIP or postal code, and country. Navigation information can also include commercial information including business and restaurant names, commercial districts, shopping centers, and parking facilities. Navigation information can also include geographical information, including information obtained from any Global Navigational Satellite infrastructure (GNSS), including Global Positioning System or Satellite (GPS), Glonass (Russian) and/or Galileo (European). The term "GPS" is used to denote any global navigational satellite system. Navigation information can include one item of information, as well as a combination of several items of information.

Service provider **100** may be configured to store energy map **120**. The term "energy map" as used throughout this detailed description and in the claims refers to any map, table, or other data structure that includes location based energy information. An energy map can provide information about the use or transformation of various types of energy as a motor vehicle travels on various roadways. An energy map is not limited to a particular type of energy and may include, but is not limited to: information about chemical energy, electrical energy, mechanical energy, nuclear energy as well as other types of energy. More specifically, an energy map can be configured to store energy information related to the use of various different power sources that could be used to power a

motor vehicle. Examples of different power sources include, but are not limited to: rechargeable energy storage systems, electricity, electrochemical devices (including batteries), combustible fuels such as hydrocarbons, fuels configured for use in fuel cells, wind, natural gas, solar power, liquid nitrogen, compressed air as well as any other power sources or energy sources. Furthermore, these different power sources can be converted to different forms of energy using power plants such as combustion engines, electric motors, fuel cells, turbines, solar panels, as well as other power plants. In particular, in a motor vehicle, these power sources can be converted to mechanical and electrical energy using one or more power plants such as a combustion engine and/or an electric motor. In some cases, the term power source can be used to describe a power plant and its associated power source.

Generally, energy map **120** can be associated with information from one or more databases. For example, in the current embodiment, energy map **120** includes information from map database **106** as well as information from energy database **108**. In other embodiments, however, a single database may store both geographical information and energy information. In still other embodiments, energy map **120** may be associated with information from three or more separate databases.

Energy map **120** includes navigation information. In the current embodiment, each of the possible routes of travel are divided into a finite number of roadway segments **122** that are connected by roadway nodes **124**. Furthermore, each roadway segment of roadway segments **122** may be associated with energy information regarding the amount of energy used, transformed or recharged as a motor vehicle travels along the roadways segment. The current embodiment illustrates two examples of energy information that can be associated with an energy map: gasoline consumption information **126** and electrical charge/discharge information **140**.

Gasoline consumption information **126** comprises gasoline consumption values **128** along each of roadways segments **122**. For example, in this embodiment, roadway segment **130** is associated with a value of 4 cc (cubic centimeters). This value indicates that motor vehicles traveling on roadway segment **130** may use approximately 4 cc of gasoline. Likewise, roadway segment **132** is associated with a value of 3 cc, which indicates that a motor vehicle traveling on roadway segment **132** uses approximately an average of 3 cc of gasoline. With this arrangement, gasoline consumption information **126** provides a method of estimating the total amount of fuel that may be consumed along a specified route comprising a plurality of roadway segments **122**.

Electrical charge/discharge information **140** comprises electrical charge/discharge values **142** along roadway segments **122**. For example, in the current embodiment, roadway segment **134** is associated with a discharge value of 0.2 (kWh) kilowatt hours. In other words, a motor vehicle traveling along roadway segment **134** using electrical power will use approximately an average of 0.2 kWh of electrical energy. As another example, roadway segment **144** is associated with a charge value of −0.2 kWh. This value indicates a motor vehicle traveling along roadway segment **144** will gain approximately an average of 0.2 kWh of electrical energy. In other words, as a motor vehicle travels along roadway segment **144**, the electric battery may be recharged as some other form of energy (such as gravitational potential energy) is transformed into electrical or chemical energy stored within an electric battery. With this arrangement, electrical charge/discharge information **140** provides a method of estimating the total amount of electrical energy that may be consumed or gained along a specified route comprising a plurality of roadway segments.

Although the current embodiment only illustrates two types of energy information, other embodiments could include additional types of energy information. For example, in some cases, an energy map could include hydrogen energy information related to the amount of hydrogen fuel that may be consumed on roadway segments by a motor vehicle that is powered with hydrogen fuel cells. In still another embodiment, an energy map could include nuclear energy information related to the amount of nuclear fuel that may be consumed on roadway segments by a motor vehicle that is powered by nuclear energy.

In different embodiments, an energy map may store information related to energy consumption as well as energy transformation or energy recharging. As discussed above, an electric battery in a motor vehicle may be recharged while traveling down a hill, and therefore some roadway segments may be associated with energy recharging values rather than energy consumption values. Some types of energy cannot be recharged while driving (such as fuels that must be refilled at stations), and therefore these types of energy will always be associated with energy consumption values. In some cases, positive and negative values can be used to distinguish between energy consumption values and energy recharging or energy restoring values. For example, in the current embodiment, positive values of energy map **120** correspond to energy consumption values while negative values correspond to energy recharging values.

It will be understood that FIG. **1** is only intended to schematically illustrate an energy map. In some cases, an energy map may be stored as a table that associates energy information with different roadway segments. In other cases, an energy map may be stored in any other form. In other words, an energy map may not include visually displayed information but may instead only comprise various collections of data stored in one or more databases.

A service provider can include provisions for determining energy information that may be used to make an energy map. In some embodiments, a service provider can measure energy increases or decreases associated with one or more power sources on various roadways. In some cases, one or more probe vehicles can measure energy information along various roadway segments.

FIG. **2** illustrates an embodiment of probe vehicle **200** in communication with service provider **100**. In some embodiments, probe vehicle **200** may communicate with service provider **100** using network **202**. In some cases, network **202** can be any kind of wireless network, including but not limited to any cellular telephone network using, for example, any one of the following standards: CDMA, TDMA, GSM, AMPS, PCS, analog, and/or W-CDMA. In other embodiments, probe vehicle **200** may not communicate wirelessly with service provider **100**. Instead, in some cases, probe vehicle may gather information remotely and then a physical connection can be established between probe vehicle **200** and service provider **100** to transfer information between them.

Probe vehicle **200** can be any type of motor vehicle that is configured to travel on one or more roadways. For purposes of clarity, only some components of probe vehicle **200** are shown. Furthermore, in other embodiments, additional components can be added or removed.

Probe vehicle **200** can include provisions for receiving GPS information. In some cases, probe vehicle **200** can include GPS receiver **206**. In an exemplary embodiment, GPS receiver **206** can be used for gathering GPS information for

any systems of a probe vehicle, including, but not limited to: GPS based navigation systems.

Probe vehicle **200** can include one or more sensors for determining various operating conditions of a motor vehicle or for determining characteristics of an environment of a motor vehicle. In one embodiment, probe vehicle **200** may include vehicle speed sensor **210** that is capable of determining the speed of probe vehicle **200**. Generally, any type of vehicle speed sensor known in the art can be used. In addition, probe vehicle **200** can include accelerometer **212** that is configured to detect g forces, as well as other types of acceleration. Furthermore, probe vehicle **200** can include altitude sensor **214** for detecting the altitude of probe vehicle **200**. Probe vehicle **200** can also include energy level sensors **216** for detecting the levels of various types of power sources. Examples of energy level sensors are discussed in detail below.

Probe vehicle **200** may include provisions for communicating, and in some cases controlling, the various components associated with probe vehicle **200**. In some embodiments, probe vehicle **200** may be associated with a computer or similar device. In the current embodiment, probe vehicle **200** may include electronic control unit **220**, hereby referred to as ECU **220**. In one embodiment, ECU **220** may be configured to communicate with, and/or control, various components of probe vehicle **200**. In addition, in some embodiments, ECU **220** may be configured to control additional components of a probe vehicle that are not shown.

ECU **220** may include a number of ports that facilitate the input and output of information and power. The term "port" as used throughout this detailed description and in the claims refers to any interface or shared boundary between two conductors. In some cases, ports can facilitate the insertion and removal of conductors. Examples of these types of ports include mechanical connectors. In other cases, ports are interfaces that generally do not provide easy insertion or removal. Examples of these types of ports include soldering or electron traces on circuit boards.

All of the following ports and provisions associated with ECU **220** are optional. Some embodiments may include a given port or provision, while others may exclude it. The following description discloses many of the possible ports and provisions that can be used, however, it should be kept in mind that not every port or provision must be used or included in a given embodiment.

In some embodiments, ECU **220** can include port **221** for communicating with GPS receiver **206**. In particular, ECU **220** may be configured to receive GPS information from GPS receiver **206**. In addition, ECU **220** can include port **222**, port **223**, port **224** and port **225** for communicating with vehicle speed sensor **210**, accelerometer **212**, altitude sensor **214** and energy level sensors **216**, respectively. With this arrangement ECU **220** can receive information from these various sensors for determining the operating parameters of probe vehicle **200**. In other embodiments, probe vehicle **200** can include provisions for communicating with additional components that are not illustrated in the current embodiment.

FIG. **3** illustrates an embodiment of various energy level sensors that could be associated with ECU **220**. In some embodiments, ECU **220** can be in communication with fuel level sensor **302** via port **321**. Generally, fuel level sensor **302** can be any type of sensor configured to measure the amount of liquid fuel in a fuel tank. For example fuel level sensor **302** can be any known sensor for detecting the amount of gasoline in a gas tank. In some cases, fuel level sensor **302** can detect the amount of a mixed fuel in a fuel tank. The term "mixed fuel" as used throughout this detailed description and in the claims, applies to a mixture of two or more fuels. For example, in some cases, a mixed fuel may be a mixture of gasoline and ethanol. Generally, mixtures of gasoline and ethanol can include different proportions of ethanol including, but not limited to: E20, E75 and E80. In other cases, fuel level sensor **302** can detect the levels of any other types of mixed fuels including, but not limited to: methanol and gasoline mixtures, p-series fuels as well as other mixed fuels.

ECU **220** may be in communication with battery charge sensor **304** via port **322**. Battery charge sensor **304** may be any sensor capable of determining the state of charge of a battery. Generally, battery charge sensor **304** may be configured to operate with any type of battery including, but not limited to: lead-acid batteries, Nickel Cadmium (NiCd) batteries, Nickel metal hydride (NiMH) batteries, lithium-ion batteries, Lithium-ion polymer batteries, nickel-zinc batteries, zinc-air batteries and molten salt batteries, as well as any other type of batteries known in the art for use with electric vehicles and/or hybrids.

ECU **220** may be in communication with hydrogen fuel sensor **306** via port **323**. Hydrogen fuel sensor **306** may be any sensor capable of determining the amount of hydrogen in a hydrogen fuel cell. Additionally, ECU **220** may be in communication with any other kind of energy sensor via additional ports. As an example, in other embodiments, ECU **220** may be in communication with energy sensors capable of detecting fuel levels in various types of fuel cells using different types of fuels. In still other embodiments, ECU **220** may be in communication with a nuclear energy sensor.

Generally, the type of energy level sensors used will depend on the types of power sources configured to power probe vehicle **200**. In other words, in situations where probe vehicle **200** is equipped with a gasoline tank for running an engine and a battery for powering an electric motor, probe vehicle **200** may include fuel level sensor **302** and batter charge sensor **304**. Likewise, in situations where probe vehicle **200** is equipped with a hydrogen fuel cell for powering a motor, probe vehicle **200** may include hydrogen fuel sensor **306**.

It should be understood that although the current embodiment discusses a probe vehicle that is used for measuring energy information on various roadways, in other embodiments energy information measurements could be made by any vehicle capable of: detecting energy use and/or energy transformation in one or more power sources; determining the location information associated with the energy information measurements and submitting the measurements and locations to a service provider. For example, in another embodiment, motor vehicles using navigation systems that are in communication with a service provider can be configured to take energy information measurements and submit the measurements along with current position information to the service provider. Typically, vehicles with different types of power sources will already be equipped with energy sensors for detecting the amount of stored energy, such as a fuel level in a fuel cell or a state of charge in a battery. With this alternative arrangement, a service provider does not need to send out dedicated probe vehicles to determine location based energy consumption information.

It will also be understood that an energy map can be created using measurements from a single vehicle, or can be created by averaging measurements from multiple vehicles. For example, multiple vehicles may take energy information measurements on a roadway segment. In some cases, these multiple measurements can be averaged together. In other cases, a single measurement can be used for each roadway segment. Furthermore, in cases where multiple measure-

ments are made by different types of vehicles, the measurements can be stored according to the type of vehicle making the measurement. In other words, in some cases, energy information measurements can be sorted according to vehicle class, make and/or model in order to provide the most accurate estimates for energy consumption or energy transformation (i.e., battery recharging) on various routes.

In some embodiments, to increase efficiency, energy consumption or restoration measured by a vehicle of a particular make and model can be used to estimate the amount of energy that may be consumed or restored by other vehicles of differing makes and/or models. For example, in some cases a probe vehicle of a particular make and model may be used to measure energy information on various roadway segments. Rather than dedicating multiple different makes and/or models to measuring energy information along the same roadway segments, the energy information measured by the probe vehicle can be used to estimate the amount of energy consumption or restoration that would be experienced by other vehicles of different makes and/or models. In some cases, this could be achieved by multiplying the measured energy information by various numerical factors that correspond to different makes and/or models.

FIG. **4** illustrates a schematic view of an embodiment of a probe vehicle configured to measure energy information. Referring to FIG. **4**, probe vehicle **200** is traveling on roadway **400**. Furthermore, probe vehicle **200** may be in communication with service provider **100**. At first location **402**, probe vehicle **200** measures first state of charge **410**. In this case, first state of charge **410** corresponds to the state of charge of a battery. In addition, probe vehicle **200** also measures first fuel level **412** at first location **402**. In this case, first fuel level **412** corresponds to the fuel level of a gas tank. Probe vehicle **200** may submit information about first state of charge **410**, information about first fuel level **412** and information about first location **402** to service provider **100**.

At second location **404**, probe vehicle **200** may measure second state of charge **414**. Second state of charge **414** corresponds to the state of charge of a battery at second location **404**. Also, probe vehicle **200** may measure second fuel level **416** at second location **404**. Probe vehicle **200** may submit information about second state of charge **414**, information about second fuel level **416** and information about second location **404** to service provider **100**.

As service provider **100** receives energy information and location information from probe vehicle **200**, service provider **100** may calculate energy consumption or energy recharging information corresponding to a particular roadway segment. In particular, service provider **100** may determine an energy level difference as a vehicle travels over a roadway segment. The term "energy level difference" as used throughout this detailed description and in the claims refers to a change in energy levels of a power source between two distinct locations. For example, service provider **100** may take the difference between first state of charge **410** and second state of charge **414** to determine a state of charge difference of the battery on a particular road segment. As previously discussed, for electric batteries, the state of charge can be decreased (battery discharge) or increased (battery recharge). Likewise, service provider **100** may take the difference between first fuel level **412** and second fuel level **416** to determine the change in the fuel level on a particular roadway segment. In other words, the difference between first fuel level **412** and second fuel level **416** gives the amount of fuel consumed on the particular roadway segment.

The current embodiment only illustrates two locations for purposes of clarity, but it may be understood that a probe vehicle may be configured to make energy level measurements at various different locations associated with a plurality of roadway segments. By making energy level measurements at multiple different locations associated with the nodes of various roadway segments, a service provider can determine energy consumption and/or recharging information for multiple roadway segments to be stored in an energy map.

Although the current embodiment only illustrates a probe vehicle measuring two kinds of energy information (the state of charge of a battery and the fuel level of a fuel tank), in other embodiments a probe vehicle could measure any other kind of energy information associated with the storage of different forms of energy for powering a vehicle. In addition, it will be understood that in some cases a probe vehicle may be configured to measure energy information related to a single power source. In other cases, a probe vehicle may measure energy information related to multiple power sources simultaneously. It will also be understood that in order to accurately determine energy consumption or energy recharging information on a roadway segment, a probe vehicle may be configured to operate using only a single power source on the roadway segment. For example, to determine the charge or discharge of an electric battery on a roadway segment, the probe vehicle may travel on the roadway segment using only battery power to prevent inaccurate estimates of electrical consumption information. Likewise, to determine fuel consumption on a roadway segment, the probe vehicle may travel on the roadway segment using only the engine to prevent inaccurate estimates of fuel consumption.

A method of making an energy map can include provisions for sorting energy information according to vehicle speed, since the amount of energy consumed or recharged may vary with the speed of the vehicle. In some cases, a probe vehicle can measure one or more energy levels associated with one or more power sources as well as the vehicle speed at various locations. This information can be used to store energy information as a function of vehicle speed.

FIG. **5** illustrates another schematic view of an embodiment of a probe vehicle configured to measure energy information. Referring to FIG. **5**, probe vehicle **200** is traveling on roadway **502**. In this case, roadway **502** comprises a series of roadway segments. In particular, roadway **502** comprises first roadway segment **511**, second roadway segment **512**, third roadway segment **513** and fourth roadway segment **514**. Furthermore, the slope of each roadway segment varies. Therefore, the amount of energy required to travel across each roadway segment may vary.

Probe vehicle **200** may measure first vehicle speed **521** and first state of charge **531** at the beginning of first roadway segment **511**. Upon entering second roadway segment **512**, probe vehicle **200** measures second vehicle speed **522** and second state of charge **532**. In this case, the difference between second state of charge **532** and first state of charge **531** indicates the amount of energy consumed on first roadway segment **511**. Next, upon entering third roadway segment **513**, probe vehicle **200** measures third vehicle speed **523** and third state of charge **533**. In this case, the difference between third state of charge **533** and second state of charge **532** indicates the amount of energy consumed on second roadway segment **512**. Moreover, since second roadway segment **512** has a greater slope than first roadway segment **511**, the amount of energy consumed along second roadway segment **512** is substantially greater than the amount of energy consumed on first roadway segment **511**. Finally, upon entering fourth roadway segment **514**, probe vehicle **200** measures fourth vehicle speed **524** and fourth state of charge **534**. In this case, the difference between fourth state of charge **534** and

third state of charge **533** indicates the amount of energy recharged on third roadway segment **513**. Specifically, since third roadway segment **513** is a down slope, the kinetic energy gained as probe vehicle **200** travels down third roadway segment **513** can be converted into electrochemical energy that is stored within a battery.

For purposes of clarity, roadway segments in the current embodiment are illustrated with approximately equal lengths. In other embodiments, however, it will be understood that the lengths of various roadway segments can vary. Furthermore, the amount of energy consumed (or recharged) on a roadway segment may vary according to various factors such as length, slope, curvature, altitude as well as other factors that could affect the consumption or recharging of energy.

FIG. **6** illustrates a schematic view of an embodiment of a battery charge/discharge table **600**. Table **600** comprises rows **602** that correspond to various roadway segments. In addition, table **600** includes columns **604** that correspond to various speed ranges. For example, first column **606** includes charge/discharge values for vehicles traveling between 0 and 9 miles per hour. Likewise, second column **608** includes charge/discharge values for vehicles traveling between 10 and 19 miles per hour. With this arrangement, an estimated charge/discharge value for each roadway segment can be stored as a function of vehicle speed for use in determining routes that minimize energy consumption.

FIG. **7** illustrates a schematic view of an embodiment of fuel consumption table **700**. Table **700** comprises rows **702** that correspond to various roadway segments. In addition, table **700** comprises columns **704** that correspond to various speed ranges. For example, first column **706** includes fuel consumption values for vehicles traveling between 0 and 9 miles per hour. Likewise, second column **708** includes fuel consumption values for vehicles traveling between 10 and 19 miles per hour. With this arrangement, an estimated fuel consumption value for each roadway segment can be stored as a function of vehicle speed for use in determining routes that minimize energy consumption.

For purposes of clarity, only some portions of table **600** and table **700** are illustrated in the current embodiment. Generally, each roadway segment in a map database may be associated with a value indicating energy consumption or recharging on that route associated with a particular type of power source. Moreover, the division of energy information values into the particular speed ranges shown here is exemplary and in other embodiments the speed ranges could have any other values. For example, in another embodiment, the speed ranges could comprise irregular increments.

Although the current embodiment uses tables with energy information sorted by speed ranges, in other embodiments energy information could be sorted using other operating parameters that may be directly or indirectly related to fuel consumption. For example, in another embodiment, a probe vehicle could measure average acceleration values over roadway segments and a service provider could build tables so that energy information values are sorted into different acceleration ranges.

It will be understood that table **600** and table **700** could be created in any manner. In some cases, a service provider may use measurements from a single probe vehicle to determine the values in table **600** and table **700**. In other cases, a service provider may use an average of a plurality of measurements from multiple probe vehicles to determine the values in table **600** and table **700**. Furthermore, the current embodiments illustrate battery charge/discharge tables and fuel consumption tables for a particular type a vehicle (such as vehicle class or vehicle model). In other embodiments, different tables can be used for different vehicle types. For example, in another embodiment, a service provider can include energy information tables for each different class of vehicle including, but not limited to, SUVs, sedans, coupes, hatchbacks, trucks as well as other vehicle types.

FIG. **8** illustrates an embodiment of a process for making an energy map. In some embodiments, some of the following steps could be accomplished by a probe vehicle, while other steps could be accomplished by a service provider. In other embodiments, however, all of the following steps could be accomplished by a probe vehicle. For example, in another embodiment, a probe vehicle may comprise a computer system with one or more databases for storing information related to an energy map. In other words, the steps of creating an energy map may be completed onboard of a probe vehicle rather than being carried out by a service provider. It will be understood that in other embodiments one or more of the following steps may be optional.

During step **802**, a probe vehicle can measure energy levels associated with one or more power sources. In some cases, a probe vehicle can measure multiple energy levels substantially simultaneously. For example, in one embodiment, a probe vehicle can measure fuel levels associated with a gasoline tank as well as state of charge levels of an electrochemical battery. In other cases, a probe vehicle may only measure a single energy level associated with a single energy storage device.

Following step **802**, during step **804**, a probe vehicle can determine a current location. In particular, in some cases a probe vehicle can determine a current location using GPS information. Next, during step **806**, the energy levels can be associated with a particular roadway segment. In some cases, the roadway segment can be selected according to the current location. Moreover, the step of associating the energy levels with a particular roadway segment can be accomplished onboard the probe vehicle or at a service provider.

Once the energy levels have been associated with a roadway segment, the energy levels can be stored in an energy map during step **808**. In some cases, the energy levels can be converted into energy difference values that correspond to the energy consumption or energy recharging that occurs on the roadway segment, rather than storing the measured energy levels. With this arrangement, an energy map can be created that can be later used to determine the amount of energy consumed or restored along a particular route.

FIG. **9** illustrates an embodiment of a detailed process for making an energy map. In some embodiments, some of the following steps could be accomplished by a probe vehicle, while other steps could be accomplished by a service provider. In other embodiments, however, all of the following steps could be accomplished by a probe vehicle. For example, in another embodiment, a probe vehicle may comprise a computer system with one or more databases for storing information related to an energy map. In other words, the steps of creating an energy map may be completed onboard of a probe vehicle rather than being carried out by a service provider. It will be understood that in other embodiments one or more of the following steps may be optional.

During step **902**, probe vehicle **200** may determine a current location. As discussed above, the current location can be determined using GPS information. Next, during step **904**, probe vehicle **200** may determine a current energy level. In other words, probe vehicle **200** may measure the energy level associated with a particular power source in the motor vehicle. As an example, probe vehicle **200** could measure the current state of charge of a battery. Following this, during step

906, probe vehicle 200 may send the current location and the current energy level to service provider 100.

Following step 906, during step 908, service provider 100 may receive the current location and the current energy level from probe vehicle 200. As discussed previously, this exchange of information could occur in any manner using wired or wireless technologies. Next, during step 910, service provider 100 may retrieve a previous location and a previous energy level associated with probe vehicle 200. In some cases, probe vehicle 200 is assumed to be constantly transmitting energy level measurements at various locations that correspond to the nodes between roadway segments.

Following step 910, during step 912, service provider 100 may determine energy information for a current route segment. In particular, the current route segment may be a route segment that extends between the previous location and the current location. In addition, the energy information corresponds to the difference between the previous energy level and the current energy level. In other words, the energy information is associated with the amount of energy consumed or recharged along the roadway segment. After step 912, during step 914, the energy map is updated with energy information for the current route segment.

It will be understood that the process discussed with respect to FIG. 9 can be repeated multiple times as a motor vehicle travels over various different roadway segments. This arrangement allows an energy map to be built by associated each of the known roadway segments in a database with energy information that indicates the amount of energy consumed or recharged on the roadway segments. Furthermore, it will be understood that the process discussed here could be repeated in order to determine energy information for different power sources along each roadway segment. For example, the process could be performed a first time to determine energy information related to the charging and discharging of a battery on a roadway segment while the motor vehicle is powered by an electric motor. The process could then be performed a second time to determine energy information related to the consumption of a combustible fuel on a roadway segment while the motor vehicle is powered by a combustion engine. This allows both fuel consumption information and battery charge/discharge information to be stored in an energy map.

A method of making an energy map can also include provisions for storing energy related roadway information. The term "energy related roadway information" as used throughout this detailed description and in the claims refers to properties of a roadway that may contribute to energy loss or transformation. For example, energy consumption is effected by length, slope, curvature, altitude as well as other properties of a roadway. In some cases, a probe vehicle may measure energy related roadway information for a particular roadway segment that is stored in an energy map by a service provider. This information can then be used at a later time to estimate energy consumption or energy recharging along one or more roadway segments. This arrangement allows for increased efficiency by providing a single set of measurements for each roadway segment that can be converted into energy losses or gains according to known properties of various different motor vehicles using different power sources.

FIG. 10 illustrates an embodiment of a detailed process for making an energy map. In some embodiments, some of the following steps could be accomplished by a probe vehicle, while other steps could be accomplished by a service provider. In other embodiments, however, all of the following steps could be accomplished by a probe vehicle. For example, in another embodiment, a probe vehicle may comprise a computer system with one or more databases for storing information related to an energy map. In other words, the steps of creating an energy map may be completed onboard of a probe vehicle rather than being carried out by a service provider. It will be understood that in other embodiments one or more of the following steps may be optional.

During step 1002, probe vehicle 200 may determine a current location. As discussed above, the current location can be determined using GPS information. Next, during step 1004, probe vehicle 200 may determine energy related roadway information. In other words, probe vehicle 200 may measure various properties of the roadway including slope, altitude, curvature as well as other properties of the roadway that may be used for estimating energy consumption or energy recharging of various power sources. In addition, the length of a particular roadway segment may also be measured where that information is not already stored in a map database. Following this, during step 1006, probe vehicle 200 may send the current location and the energy related roadway information to service provider 100.

Following step 1006, during step 1008, service provider 100 may receive the current location and the energy related roadway information from probe vehicle 200. As discussed previously, this exchange of information could occur in any manner using wired or wireless technologies. Next, during step 1010, service provider 100 may select a current route segment associated with the current location. After step 1010, during step 1020, the energy map is updated with energy related roadway information for the current route segment.

FIG. 11 illustrates a schematic view of an embodiment of motor vehicle 1102. Generally, motor vehicle 1102 may be propelled by any power source. In some embodiments, motor vehicle 1102 may be configured as a hybrid vehicle that uses two or more power sources. In an exemplary embodiment, motor vehicle 1102 includes engine 1110 and electric motor 1112. In particular, engine 1110 may generate power using fuel from fuel tank 1114. Likewise, electric motor 1112 may generate electrical energy using battery 1116. In other embodiments, motor vehicle 1102 could include any other power sources.

Engine 1110 and electric motor 1112 may be configured to power motor vehicle 1102 in any manner. In some embodiments, motor vehicle 1102 may use a parallel type of hybrid design. In other embodiments, motor vehicle 1102 may use a series type of hybrid design. In still other embodiments, any known hybrid design can be used for motor vehicle 1102.

Motor vehicle 1102 can include provisions for receiving GPS information. In some cases, motor vehicle 1102 can include GPS receiver 1122. In an exemplary embodiment, GPS receiver 1122 can be used for gathering GPS information for any systems of a probe vehicle, including, but not limited to: GPS based navigation systems.

Motor vehicle 1102 can include one or more sensors for determining various operating conditions of a motor vehicle or for determining characteristics of an environment of a motor vehicle. In one embodiment, motor vehicle 1102 can include battery charge sensor 1124 for sensing the state of charge of battery 1116. Battery charge sensor 1124 can be any type of charge sensor known in the art for detecting the state of charge of a battery. In addition, motor vehicle 1102 can include fuel tank sensor 1126 for sensing the amount of fuel in fuel tank 1114. Fuel tank sensor 1126 can be any type of fuel sensor known in the art for detecting the amount of fuel in a fuel tank. In embodiments where motor vehicle includes other types of power sources, a motor vehicle can also be equipped with various other sensors for detecting the energy levels of each power source.

Motor vehicle **1102** can include provisions for communicating, and in some cases controlling, the various components associated with motor vehicle **1102**. In some embodiments, motor vehicle **1102** may be associated with a computer or similar device. In the current embodiment, motor vehicle **1102** may include electronic control unit **1150**, hereby referred to as ECU **1150**. In one embodiment, ECU **1150** may be configured to communicate with, and/or control, various components of motor vehicle **1102**. In addition, in some embodiments, ECU **1150** may be configured to control additional components of a motor vehicle that are not shown.

ECU **1150** may include a number of ports that facilitate the input and output of information and power. The term "port" as used throughout this detailed description and in the claims refers to any interface or shared boundary between two conductors. In some cases, ports can facilitate the insertion and removal of conductors. Examples of these types of ports include mechanical connectors. In other cases, ports are interfaces that generally do not provide easy insertion or removal. Examples of these types of ports include soldering or electron traces on circuit boards.

All of the following ports and provisions associated with ECU **1150** are optional. Some embodiments may include a given port or provision, while others may exclude it. The following description discloses many of the possible ports and provisions that can be used, however, it should be kept in mind that not every port or provision must be used or included in a given embodiment.

ECU **1150** can include port **1151** for communicating with GPS receiver **1122**. Additionally ECU **1150** can include port **1152** and port **1153** for communicating with battery charge sensor **1124** and fuel tank sensor **1126**, respectively. In order to provide visual information to a user, ECU **1150** can include a display port **1154** that is capable of interacting with a display device **1130**. To receive input from a user, ECU **1150** can include an input port **1155**. Input port **1155** can communicate with input device **1132**. In some embodiments, display device **1130** can also receive input from a user. In some embodiments, display device **1130** includes a touch screen that can receive input and in other embodiments, display device **1130** includes a number of buttons that can receive input. In some embodiments, display device **1130** includes both a touch screen and buttons.

Motor vehicle **1102** can include provisions for controlling one or more power sources. In one embodiment, ECU **1150** may be configured to control engine **1110** and electric motor **1112**. In particular, in the current example, ECU **1150** may include port **1156** for communicating with engine **1110** and port **1157** for communicating with electric motor **1112**. For purposes of clarity, the connection between ECU **1150** and engine **1110** is shown as a single connection associated with a single port of ECU **1150**. However, it will be understood that in some cases, ECU **1150** may be in communication with multiple components that effect the operation of engine **1110** including, but not limited to: fuel injectors, throttle valves, spark plugs, as well as other electrical components that are used for controlling the operating of engine **1110**. Furthermore, in some cases, electric motor **1112** may be controlled using a single port, while in other embodiments ECU **1150** can be connected to electric motor **1112** using multiple ports.

In some embodiments, some of the resources associated with ECU **1150** may be configured to operate as a portion of a navigation system. In particular, in some cases, ECU **1150** may be configured to display navigation information on display screen **1130**. ECU **1150** may also receive navigation information from GPS receiver **1122**. Furthermore, ECU **1150** can receive input from a user from display screen **1130** and/or input device **1132**.

Although the current embodiment illustrates a single ECU, in other embodiments multiple control units could be used. For example, in another embodiment, a separate control unit could be used in conjunction with navigation and with controlling one or more power sources in motor vehicle **1102**. In other words, in some cases, motor vehicle **1102** could include a dedicated navigation control unit as well as a dedicated power source control unit for controlling one or more power sources in a motor vehicle.

In some embodiments, some of the items shown in FIG. **11** can be a housed in a single case or unit. In other embodiments, the various items shown in FIG. **11** are not housed in a single physical case, but instead, are distributed throughout motor vehicle **1102** and communicate with one another via known wired or wireless methods. For example, in a system where one or more items communicate wirelessly, the Bluetooth® protocol can be used. Furthermore, in some cases, one or more components can communicate with one another using a controller area network within motor vehicle **1102**.

FIG. **12** illustrates an exemplary embodiment of a system for providing a motor vehicle with navigation information. Referring to FIG. **12**, motor vehicle **1102** may be in communicate with service provider **100** using wireless network **1202**. Wireless network **1202** can be any kind of wireless network, including but limited to any cellular telephone network using, for example, any one of the following standards: CDMA, TDMA, GSM, AMPS, PCS, analog, and/or W-CDMA.

In an exemplary embodiment, motor vehicle **1102** includes navigation system **1210** for providing navigation information to a user. As an example, in some cases, a user can input a starting location and an ending location (or destination) and navigation system **1210** may provide a route for the user to travel. In the current embodiment, navigation information may be exchanged between motor vehicle **1102** and service provider **100** through wireless network **1202**. Moreover, in the exemplary embodiment, navigation system **1210** may serve as a client that relies on service provider **100** for some or all of the processing of the navigation information including determining optimized routes for motor vehicle **1102**. However, it will be understood that in other embodiments navigation system **1210** may operate as a standalone system that processes information onboard of motor vehicle **1102**. In particular, in some cases, navigation system **1210** could include onboard databases for retrieving map-based information related to finding navigation routes for motor vehicle **1102**.

For purposes of understanding the embodiments discussed below, the term "minimum energy route" is used. A minimum energy route may be any route that reduces the energy used by one or more power sources. It should be understood that a minimum energy route may not necessarily refer to a route that reduces the total amount of energy consumed by a motor vehicle, but instead may refer to a route that minimizes the energy consumed by a particular power source associated with the motor vehicle. For example, in some cases, a minimum energy route may refer to a route that minimizes fuel consumption by an engine. In other cases, a minimum energy route may refer to a route that minimizes the amount of electrical energy discharged by a battery used with an electric motor. In still other cases, a minimum energy route may refer to a route that minimizes the total amount of energy consumed by both an engine and an electric motor in the form of fuel and electricity.

FIG. **13** illustrates an embodiment of a process for managing navigation information. In some embodiments, some of the following steps could be accomplished by a motor vehicle, while other steps could be accomplished by a service provider. Specifically, in some cases, steps associated with the motor vehicle could be accomplished by an electronic control unit or any combination of control units or processors of the motor vehicle. In other embodiments, however, all of the following steps could be accomplished by a motor vehicle. For example, in another embodiment, a motor vehicle may comprise a computer system with one or more provisions for calculating a navigational route that is optimized to minimize energy consumption. In other words, the steps of preparing navigational information may be completed onboard of a motor vehicle rather than being carried out by a service provider. It will be understood that in other embodiments one or more of the following steps may be optional.

As shown in FIG. **13**, the process begins when an input is received in step **1302**. Any form of input can be received in step **1302**. In some cases, the input is in the form of one or more buttons being pressed, and/or interaction with a touch screen associated with display device **1130** (see FIG. **11**). In some cases, a combination of input from buttons and/or touch screen interaction is received.

It is also possible for voice information to be received in step **1302**. Any known speech recognition process or program can be utilized to convert spoken words, phrases and/or numbers into a machine readable format. Preferably, the IBM® embedded Via Voice speech recognition engine is used.

During step **1304**, the energy levels of one or more power sources can be sensed. In particular, in some cases, information can be received from one or more energy level sensors. For example, in one embodiment, information related to the amount of fuel in a fuel tank can be received from fuel tank sensor **1126** (see FIG. **11**). Likewise, information related to the state of charge of a battery can be received from battery charge sensor **1124** (see FIG. **11**). In an embodiment where a fuel cell is used, information can be received from a fuel level sensor that measures the amount of fuel in the fuel cell.

Next, during step **1306**, a minimum energy route request can be prepared. In some cases, this step can be performed by ECU **1150** (see FIG. **11**). In other cases, a separate navigation control unit can perform this step. After step **1306**, the minimum energy route request and the energy levels can be sent during step **1308**.

During step **1310**, service provider **100** may receive the minimum energy route request. Next, during step **1312**, service provider **100** may prepare navigational information and energy management information related to the minimum energy route request. The term "energy management information" as used throughout this detailed description and in the claims refers to any information that may be utilized by a motor vehicle to operate one or more power sources along a preselected route to achieve optimal use of energy. For example, energy management information can include information related to traffic congestion along a predetermined route. Energy management information can also include information related to the slope of a roadway. This energy management information can then be used by a motor vehicle to optimize control of one or more power sources to minimize energy consumption.

During step **1314**, service provider **100** may send navigation information and energy management information to motor vehicle **1102**. Next, during step **1316**, motor vehicle **1102** may receive the navigation information and the energy management information. Following this, during step **1318**, motor vehicle **1102** may process the navigation information. In some cases, this step can include recalculating the route selected by the server.

During step **1320**, motor vehicle **100** may provide navigation information to a user. In some cases, a navigation route can be provided on display device **1130**. In other cases, audible navigation information can be generated to instruct a user on where to turn.

During step **1322**, motor vehicle **100** can control one or more power sources using the energy management information. For example, in embodiments including an engine and an electric motor, motor vehicle **1102** can use the energy management information to switch between the engine and the electric motor at various points along the route. This arrangement may help reduce energy consumption by maximizing the use of the electric motor over the engine.

FIG. **14** illustrates an embodiment of a general process of preparing navigational information and energy management information. Initially, during step **1402**, service provider **100** may receive a starting location and an ending location. Next, during step **1404**, service provider **100** may retrieve an energy map. As previously discussed, an energy map may be stored in one or more databases associated with service provider **100** and can contain energy information related to one or more power sources for a motor vehicle.

During step **1406**, service provider **100** may calculate a minimum energy route. Generally, a minimum energy route can be calculated using any known optimization algorithms. In some cases, a minimum energy route can be calculated by minimizing the amount of energy consumed by a single power source associated with the motor vehicle. In other cases, a minimum energy route can be calculated by minimizing the amount of energy consumed by two or more power sources. During step **1408**, service provider **100** may determine energy management information associated with the minimum energy route. In particular, service provider **100** may determine any information that may be utilized by a motor vehicle to control one or more power sources while traveling on a minimum energy route.

FIG. **15** illustrates another embodiment of a process of preparing navigational information and energy management information. This particular process may be used in situations where an energy map is a charge/discharge map related to the charge or discharge of a battery along various roadway segments. Initially, during step **1502**, service provider **100** may receive a starting location and an ending location. Next, during step **1504**, service provider **100** may retrieve a charge/discharge map. As previously discussed, a charge/discharge map may be stored in one or more databases associated with service provider **100** and can contain energy information related to energy discharged or energy recharged by a battery that powers an electric motor.

The method discussed and shown in FIG. **15** can be utilized with hybrid vehicles or electric vehicles including electric motors powered by batteries. For example, this method can be used to determine the minimum electrical consumption route for an electric vehicle between a starting location and an ending location.

During step **1506**, service provider **100** may calculate a minimum electrical consumption route that minimizes the amount of electricity discharged by a battery for powering an electric motor. Generally, any known optimization algorithms can be used to calculate a minimum electrical consumption route. During step **1508**, service provider **100** may determine energy management information associated with the minimum electrical consumption route. In particular, service provider **100** may determine any information that may be

utilized by a motor vehicle to control an electric motor while the motor vehicle travels on the minimum electrical consumption route.

FIG. **16** illustrates another embodiment of a process of preparing navigational information and energy management information. This detailed process may be used in situations where an energy map is a charge/discharge map related to the charge or discharge of a battery along various roadway segments. Initially, during step **1602**, service provider **100** may receive a starting location and an ending location. Next, during step **1604**, service provider **100** may retrieve a charge/discharge map. As previously discussed, a charge/discharge map may be stored in one or more databases associated with service provider **100** and can contain energy information related to energy discharged or energy recharged by a battery that powers an electric motor.

During step **1606**, service provider **100** may calculate an optimal route that minimizes the status of both battery overcharge and battery empty. The term "battery overcharge" refers to a state of a battery in which the battery is fully charged and cannot accommodate further recharging. By minimizing battery overcharge and battery empty conditions, a vehicle more efficiently uses the engine and the electric motor to conserve fuel and reduce emissions. Generally, any known optimization algorithms can be used to calculate this kind of optimized route. During step **1608**, service provider **100** may determine energy management information associated with the minimum electrical consumption route. In particular, service provider **100** may determine any information that may be utilized by a motor vehicle to control an electric motor while the motor vehicle travels on the optimal route.

FIGS. **17** through **21** illustrate an embodiment of a method of managing navigation information. Referring to FIG. **17**, a user may select a type of route from display screen **1130** of a navigation system. In traditional systems, the fastest routes between a starting point and an ending point are chosen. However, the current embodiment illustrates a system that allows a user to select between fastest route option **1702** and eco route option **1704** (or ecological route option **1704**) that minimizes the amount of energy expended and/or reduces the amount of fuel consumed. By selecting an eco route, a user can save fuel costs and reduce emissions generated by a gasoline engine or other types of power sources that give off emissions.

FIG. **18** illustrates an embodiment of a navigation request being sent to a service provider. In particular, navigation system **1210** has received starting point **1802** and ending point **1804** from a user and/or a GPS receiver. Furthermore, a user has requested a route between starting point **1802** and ending portion **1804** that is a minimum energy route. A navigation request is then sent over wireless network **1202** to service provider **100**, as previously discussed.

FIG. **19** illustrates a schematic view of an embodiment of a route calculation unit **1900**. Route calculation unit **1900** may receive various inputs and produces as an output minimum energy route **1910**. As an example, the current embodiment illustrates several possible inputs. Route calculation unit **1900** may receive user starting point and ending point information **1901**. This information may be associated with the current location of the user and the destination of the user. In some cases, route calculation unit **1900** may receive information from energy map **1902**. In some cases, this information can be obtained from one or more databases including a map database and an energy database. Also, route calculation unit **1900** may receive traffic information **1904**. Traffic information **1904** can include traffic speed information along various roadways as well as real-time or average traffic congestion information. In some cases, route calculation unit **1900** may also receive roadway information such as road slope information **1906**. It will be understood that in other embodiments, other types of input could be received by route calculation unit **1900**.

It will be understood that route calculation unit **1900** can be any type of calculation unit. Algorithms for optimizing routes are known in the art. In an exemplary embodiment, route calculation unit **1900** comprises one or more algorithms that are configured to optimize routes between a starting point and an ending point.

FIG. **20** illustrates a schematic view of an embodiment of a method of selecting an optimized route that minimizes energy use. Referring to FIG. **20**, a route calculation unit may calculate three possible routes between starting point **1802** and ending point **1804**. In particular, the route calculation unit may calculate first route **2002**, second route **2004** and third route **2006**.

In this example, route calculating unit **1900** may be configured to select a route that minimizes over charge and battery empty conditions for a battery. For example, first route **2002** is associated with first battery status profile **2010**, second route **2004** is associated with second battery status profile **2012** and third route **2006** is associated with third battery status profile **2014**. In this case, first battery status profile **2010** is associated with battery overcharge period **2020**. In addition, third battery status profile **2014** is associated with battery empty period **2022**. In contrast, second battery status profile **2012** is not associated with any periods of battery overcharge or battery undercharge. In other words, second route **2004** is the route that minimizes the amount of battery overcharge and battery overcharge. Therefore, the route calculation unit may select second route **2004** as the optimal or minimum energy route.

Referring to FIG. **21**, service provider **100** sends navigation information and energy management information back to navigation system **1210** of motor vehicle **1102**. In this case, the navigation information is displayed on display screen **1130**. Furthermore, the displayed route corresponds to second route **2004** which is the minimum energy route calculated by service provider **100**. At this point, the navigation system can start providing directions to a user to travel on second route **2004** towards ending point **1804**.

In some embodiments, a system may be configured to display energy savings information **2100**. In this case, energy savings information **2100** can include information related to the amount gasoline saved. In other cases, however, the energy savings information can be used to display the amount of electricity saved. In still other cases, the energy savings information can be used to display the amount of fuel saved associated with a fuel cell of some kind.

In order to minimize the energy consumed on a route provided by a service provider, a motor vehicle may use energy management information that is associated with a minimum energy route to control one or more power sources. As previously discussed, energy management information can include various information associated with a predetermined route that allows a vehicle to optimize the use of energy and reduce overall energy consumption.

FIGS. **22** and **23** illustrate a schematic embodiment of minimum energy route **2200** and energy management information table **2300** that is associated with minimum energy route **2200**. Referring to FIGS. **22** and **23**, minimum energy route **2200** comprises a plurality of roadway segments A, B, C, D, E and F. These segments are reproduced within energy management information table **2300**. Furthermore, additional information associated with each of these segments is

provided in table **2300**. Specifically, each of the segments are listed in first row **2302**. Furthermore, charge/discharge information is indicated in second row **2304**, slope information is indicated in third row **2306**, congestion information is indicated in fourth row **2308** and fuel use information is indicated in fifth row **2310**.

The information provided in table **2300** may be used by a motor vehicle to precisely control the use of an electric motor and an engine as it travels on minimum energy route **2200**. Examples are discussed in detail below. However, it should be understood that the types of information listed in the current embodiment are optional. In other cases, some of these types of information can be removed, while other types of information can be added.

FIGS. **24** and **25** illustrate embodiments of motor vehicles traveling on a predetermined route. In particular, FIG. **24** illustrates an embodiment of motor vehicle **2400** traveling on route **2402** without any access to energy management information and FIG. **25** illustrates an embodiment of motor vehicle **1102** traveling on the same route with access to energy management information.

Referring to FIG. **24**, motor vehicle **2400** initially travels on flattened roadway segment **2404** using energy from an electric motor and switches to using energy from the engine at first location **2408** to avoid reducing the battery charge below a predetermined margin. At this point, the battery is half charged as shown by state of charge indicator **2410**. Furthermore, motor vehicle **2400** may travel down sloped roadway segment **2406**, which slopes downwardly. As motor vehicle **2400** travels on sloped roadway segment **2406**, the battery is overcharged. This results in a loss of energy that could have been recharged along sloped roadway segment **2406**. In this embodiment, the lack of energy management information prevents motor vehicle **2400** from efficiently using the engine and motor over both flattened roadway segment **2404** and sloped roadway segment **2406** to minimize energy use.

Referring to FIG. **25**, motor vehicle **1102** has access to energy management information that may be utilized to make decisions in operating the engine and/or electric motor. In this case, motor vehicle **1102** is initially traveling on flattened roadway segment **2404** using energy from an electric motor. In addition, the energy management information provided to motor vehicle **1102** indicates that motor vehicle **1102** is approaching sloped roadway segment **2406**. Therefore, motor vehicle **1102** may make use of the electric motor for a longer period of time since the battery can be recharged at sloped roadway segment **2406**. In particular, motor vehicle **1102** may reduce the lower margin of battery charge since information is provided about an upcoming down slope. In this case, motor vehicle **1102** switches to the engine at second location **2508**. At second location **2508**, the state of charge is close to empty as indicated by state of charge indicator **2510**. Following this, the battery can recharge on sloped roadway segment **2406**. This arrangement helps to reduce fuel consumption by increasing the amount of time that the electric motor is used along a route. In particular, when using the above described methods a motor vehicle can optimize the use of the electric motor and the battery along a predetermined route to minimize the amount of fuel used on the route.

FIGS. **26** and **27** illustrate embodiments of motor vehicles traveling on a predetermined route. In particular, FIG. **26** illustrates an embodiment of motor vehicle **2600** traveling on route **2602** without any access to energy management information and FIG. **27** illustrates an embodiment of motor vehicle **1102** traveling on the same route with access to energy management information.

Referring to FIG. **26**, route **2602** may be divided into high speed segment **2630** and low speed segment **2632** that is associated with traffic congestion **2620**. Motor vehicle **2600** initially travels on high speed segment **2630** using a combination of the electric motor and the engine. While traveling on high speed segment **2630**, the battery is discharged to a predetermined lower margin of batter charge, as indicated by state of charge indicator **2610**. As motor vehicle **2600** travels through low speed segment **2632** that is associated with traffic congestion **2620**, motor vehicle **2600** may be powered by the battery for a short period of time until the battery is empty. Once the battery is empty, motor vehicle **2600** may be powered by the engine. However, the engine is less efficient at the lower speeds that occur in congestion and therefore motor vehicle **2600** is unable to use the engine and the motor most efficiently on route **2602**.

In contrast, referring to FIG. **27**, motor vehicle **1102** has access to energy management information that may be utilized to make decisions in operating the engine and/or electric motor. In this case, motor vehicle **1102** travels on high speed segment **2630** using only the engine, since the energy management information indicates that motor vehicle **1102** is approaching low speed segment **2632** that is associated with traffic congestion **2620**. In other words, the battery stays fully charged throughout high speed segment **2630** as indicated by state of charge indicator **2710**. This allows motor vehicle **1102** to run on battery power throughout the entirety of low speed segment **2632**. With this configuration, motor vehicle **1102** may be powered by the engine at higher speeds where the engine is most efficient and by the electric motor at lower speeds where the electric motor is most efficient.

In some embodiments, a motor vehicle can include provisions for calculating minimum energy routes directly, rather than requesting minimum energy routes from a remote service provider. In some cases, a motor vehicle can be provided with an onboard database that includes map information and energy information.

FIG. **28** illustrates another embodiment of motor vehicle **2802**. Motor vehicle **2802** can be provided with substantially similar provisions to the embodiment discussed above and illustrated in FIG. **11** including ECU **2850** that is substantially similar to ECU **1150** of the previous embodiment. In this case, motor vehicle **2802** can be provided with onboard database **2810**. In some cases, database **2810** can include mapping information. In other cases, database **2810** can include energy information. In an exemplary embodiment, database **2810** can include mapping information and energy information.

Motor vehicle **2802** can also include route calculating unit **2830** which is capable of calculating various kinds of routes according to navigational information and energy information. In some cases, route calculating unit **2830** may be separate from ECU **2850**. In other cases, route calculating unit **2830** may be embedded within ECU **2850**. Furthermore, in some cases, route calculating unit **2830** may be directly connected to database **2810**.

In this case, ECU **2850** can include port **2820** for communicating with database **2810**. In particular, ECU **2850** may be configured to send information to database **2810** and receive information from database **2810**. ECU **2850** can also include port **2822** for communicating with route calculating unit **2830**. Using this arrangement, motor vehicle **2850** may be capable of calculating minimum energy routes and providing a user with navigation information related to the minimum energy routes. Furthermore, motor vehicle **2802** may be configured to calculate energy management information associated with a minimum energy route for controlling one or more power sources along the minimum energy route.

FIG. **29** illustrates an embodiment of a method of determining a minimum energy route and energy management information. In this case, each of the following steps are performed by one or more resources of motor vehicle **2802**. In particular, in some cases, one or more of the following steps may be performed by ECU **2850**. It will be understood that in other embodiments, some of these steps could be optional.

During step **2902**, input from a user may be received. In particular, a starting location and an ending location can be received. In some cases, the starting location can be received directly from a GPS receiver. Next, during step **2904**, an energy map can be retrieved. In this case, ECU **2850** or route calculating unit **2830** may receive information from database **2810** (see FIG. **28**).

During step **2906**, a minimum energy route can be calculated by route calculation unit **2830**. Next, during step **2908** energy management information can be determined that corresponds to the minimum energy route. In some cases, this information can be determined by route calculating unit **2830**. In other cases, this information can be determined by ECU **2850**. In still other cases, this information can be determined by another calculating unit.

During step **2910** directions may be provided to a user that correspond to the minimum energy route. In some cases, the directions can be displayed for the user. Following this, during step **2912**, one or more power sources can be controlled using the energy management information. In the exemplary embodiment, the energy management information can be used to control the engine and the electric motor.

It will be understood that the principles discussed above are not limited to use with hybrid vehicles that utilize two or more different power sources. Instead, these principles can be used in conjunction with vehicles powered by a single power source. Examples include vehicles powered only by a combustible fuel using an engine and vehicles powered only by a battery using an electric motor. In these cases, an energy map used for calculating minimum energy routes may only include information related to a single power source associated with the motor vehicle. For example, to calculate a minimum electrical consumption route for an electric vehicle, a charge/discharge map can be used by a server. Likewise, to calculate a minimum gasoline consumption route, a gasoline consumption map can be used by a server.

While various embodiments have been described, the description is intended to be exemplary, rather than limiting and it will be apparent to those of ordinary skill in the art that many more embodiments and implementations are possible that are within the scope of the claims. Accordingly, the embodiments are not to be restricted except in light of the attached claims and their equivalents. Also, various modifications and changes may be made within the scope of the attached claims.

What is claimed is:

1. A method of operating a motor vehicle including an electronic control unit, the electronic control unit being configured to perform the method comprising the steps of:

determining a first location of the motor vehicle, the first location corresponding to a first portion of a roadway segment;

measuring a value of a first state of charge of a battery at the first location;

measuring a value of a first fuel level of a fuel tank at the first location;

determining a second location of the motor vehicle, the second location corresponding to a second portion of the roadway segment that is different from the first portion;

measuring a value of a second state of charge of the battery at the second location;

measuring a value of a second fuel level of a fuel tank at the second location;

submitting the first state of charge value, the first fuel level value, and the first location to a service provider; and

submitting the second state of charge value, the second fuel level value, and the second location to the service provider; and

wherein the service provider is configured to determine a difference between the first state of charge value and the second state of charge value and a difference between the first fuel level value and the second fuel level value for the roadway segment between the first location and the second location.

2. The method according to claim **1**, wherein the steps are accomplished by an electronic control unit disposed in a probe vehicle.

3. The method according to claim **1**, wherein the first location and the second location are determined using a GPS receiver.

4. The method according to claim **1**, wherein the first state of charge value and the second state of charge value are measured using a state of charge sensor.

5. The method according to claim **1**, wherein the method further comprises the steps of:

determining a plurality of locations corresponding to links on a route;

measuring a plurality of state of charge values associated with each of the links;

measuring a plurality of fuel level values associated with each of the links;

submitting the plurality of state of charge values, the plurality of fuel level values, and the plurality of locations to the service provider; and

wherein the service provider is configured to determine a difference between the plurality of state of charge values for each of the links and a difference between the plurality of fuel level values for each of the links.

6. The method according to claim **1**, wherein the first state of charge value, the second state of charge value, the first fuel level value, the second fuel level value, the first location and the second location are submitted to the service provider over a wireless network.

7. A method of making an energy map using a computer system, the computer system being configured to perform the method comprising the steps of:

receiving information related to a current state of charge of a battery in a motor vehicle;

receiving information related to a current fuel level of a fuel tank in the motor vehicle;

receiving a current location of the motor vehicle;

retrieving a previous state of charge associated with the motor vehicle;

retrieving a previous fuel level associated with the motor vehicle;

retrieving a previous location of the motor vehicle, the previous location being associated with the previous state of charge and the previous fuel level;

determining a roadway segment extending between the previous location and the current location;

determining a state of charge difference between the previous state of charge and the current state of charge;

determining a fuel level difference between the previous fuel level and the current fuel level; and

associating the state of charge difference and the fuel level difference with the roadway segment in the energy map.

8. The method according to claim 7, wherein the current location is determined using a GPS receiver.

9. The method according to claim 7, wherein the step of associating the state of charge difference with the roadway segment includes a step of averaging the state of charge difference with a plurality of state of charge differences associated with the roadway segment.

10. The method according to claim 7, wherein the state of charge difference is a discharge value indicating the amount of electricity consumed during travel along the roadway segment.

11. The method according to claim 7, wherein the state of charge difference is a charge value indicating the amount of electricity recharged during travel along the roadway segment.

12. The method according to claim 7, wherein the state of charge information and the fuel level information is received from a probe vehicle.

13. A method of operating a motor vehicle including an electronic control unit, the electronic control unit being configured to perform the method comprising the steps of:

determining a first location of the motor vehicle;

measuring a first energy level of a first power source and measuring a second energy level of a second power source at the first location, wherein the first power source is different than the second power source;

determining a second location of the motor vehicle, the second location being different than the first location;

measuring a third energy level of the first power source and measuring a fourth energy level of the second power source at the second location;

submitting the first energy level, the second energy level, the third energy level, the fourth energy level, the first location, and the second location to a service provider; and

wherein the service provider is configured to determine a difference between the first energy level and the third energy level and a difference between the second energy level and the fourth energy level, and to associate each difference with a road segment located between the first location and the second location.

14. The method according to claim 13, wherein the first power source is a battery.

15. The method according to claim 14, wherein the second power source is combustible fuel.

16. The method according to claim 14, wherein the second power source is a hydrogen fuel cell.

17. The method according to claim 13, wherein the first power source is a fuel cell and wherein the second power source is a battery.

18. The method according to claim 13, wherein the method further comprises a step of determining a plurality of locations corresponding to nodes on a route.

19. The method according to claim 18, wherein the method further comprises a step of making a plurality of energy level measurements for the first power source and the second power source at the plurality of locations and submitting the plurality of energy level measurements to the service provider.

20. A method of making an energy map using a computer system, the computer system being configured to perform the method comprising the steps of:

receiving information related to a first energy level of a first power source;

receiving information related to a second energy level of a second power source, the second power source being different than the first power source;

receiving information related to a current location;

retrieving a first previous energy level associated with the first power source;

retrieving a second previous energy level associated with the second power source;

retrieving a previous location;

determining a roadway segment extending between the previous location and the current location;

determining a first energy level difference between the first previous energy level and the first energy level;

determining a second energy level difference between the second previous energy level and the second energy level; and

associating the first energy level difference and the second energy level difference with the roadway segment to make the energy map.

21. The method according to claim 20, wherein the first energy level difference is an electrical charge value associated with a battery.

22. The method according to claim 20, wherein the first energy level difference is an electrical discharge value associated with a battery.

23. The method according to claim 22, wherein the second energy level difference is a fuel consumption value associated with a combustible fuel.

24. The method according to claim 22, wherein the second energy level difference is a fuel consumption value associated with a fuel cell.

25. The method according to claim 24, wherein the second energy level difference is a hydrogen fuel consumption value.

26. The method according to claim 20, wherein the second energy level difference is a nuclear energy consumption value.

27. The method according to claim 20, further comprising the steps of:

receiving information related to a current roadway segment;

receiving energy related roadway information about the current roadway segment; and

associating the energy related roadway information with the current roadway segment in the energy map.

28. The method according to claim 27, wherein the energy related roadway information includes slope information.

29. The method according to claim 27, wherein the energy related roadway information includes curvature information.

30. The method according to claim 27, wherein the energy related roadway information includes altitude information.

31. The method according to claim 27, wherein the energy related roadway information includes information that may be used to estimate energy consumption along the roadway segment.

32. The method according to claim 31, wherein the energy related roadway information includes information that may be used to estimate energy recharging along the roadway segment.

33. The method according to claim 27, wherein the energy related roadway information is configured to be used with different types of vehicles.

34. A method of making an energy map using a computer system, the computer system being configured to perform the method comprising the steps of:

receiving information related to a roadway segment;

receiving operating conditions associated with a motor vehicle;

determining a first vehicle speed associated with the roadway segment;

determining a first state of charge difference associated with traveling on the roadway segment at the first vehicle speed;

determining a first fuel level difference associated with traveling on the roadway segment at the first vehicle speed;

determining a second vehicle speed associated with roadway segment, the second vehicle speed being different from the first vehicle speed;

determining a second state of charge difference associated with traveling on the roadway segment at the second vehicle speed;

determining a second fuel level difference associated with traveling on the roadway segment at the second vehicle speed; and

storing the first state of charge difference and the first fuel level difference in a first speed range associated with the roadway segment and storing the second state of charge difference and the second fuel level difference in a second speed range associated with the roadway segment, the first speed range being different than the second speed range and wherein the first vehicle speed is within the first speed range and wherein the second vehicle speed is within the second speed range.

35. The method according to claim **34**, wherein the first state of charge difference is substantially different from the second state of charge difference.

36. The method according to claim **34**, wherein the first state of charge difference is substantially similar to the second state of charge difference.

37. The method according to claim **34**, wherein the first state of charge difference is determined using state of charge measurements along different locations of the roadway segment while the vehicle is traveling at the first vehicle speed.

38. The method according to claim **37**, wherein the second state of charge difference value is determined using state of charge measurements along different locations of the roadway segment while the vehicle is traveling at the second vehicle speed.

39. The method according to claim **38**, wherein the state of charge measurements associated with the first state of charge difference are taken at a substantially different time than the state of charge measurements associated with the second state of charge difference.

* * * * *