US006636790B1

(12) **United States Patent**
Lightner et al.

(10) **Patent No.: US 6,636,790 B1**
(45) **Date of Patent: Oct. 21, 2003**

(54) **WIRELESS DIAGNOSTIC SYSTEM AND METHOD FOR MONITORING VEHICLES**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/776,106**

(22) Filed: **Feb. 1, 2001**

Related U.S. Application Data

(60) Provisional application No. 60/222,152, filed on Aug. 1, 2000, provisional application No. 60/222,213, filed on Aug. 1, 2000, and provisional application No. 60/220,986, filed on Jul. 25, 2000.

(51) **Int. Cl.**[7] **G06F 7/00**
(52) **U.S. Cl.** **701/33**; 701/29
(58) **Field of Search** 701/29, 30, 33, 701/35; 73/116, 117.2

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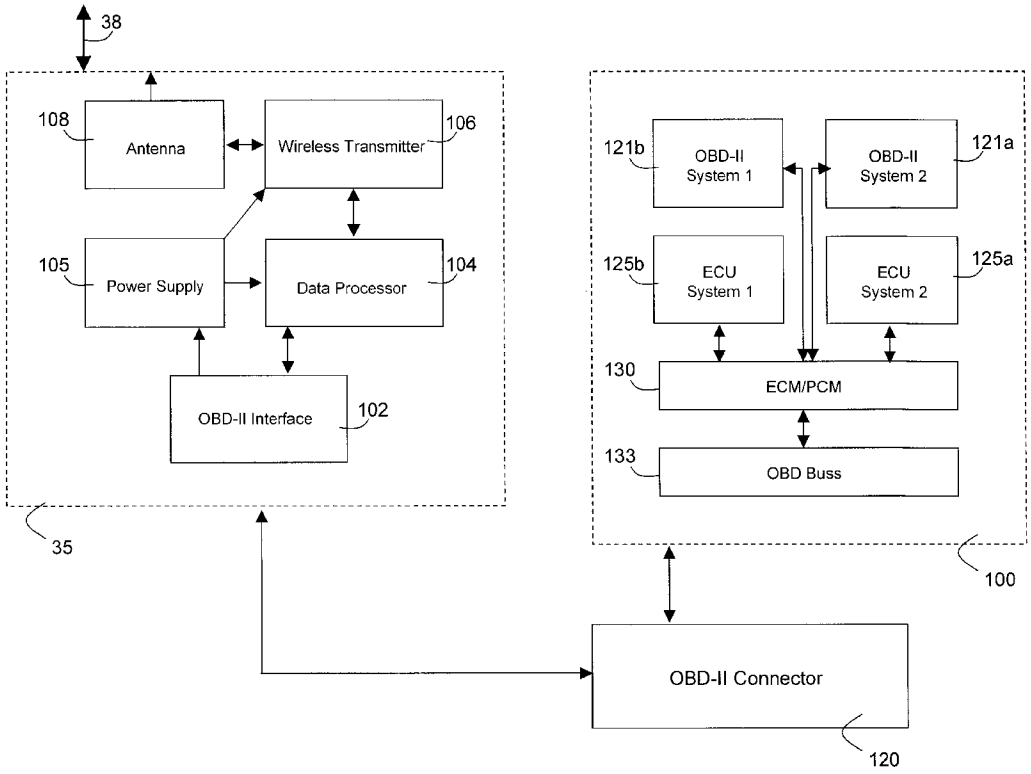
(57) **ABSTRACT**

A method and apparatus for remotely characterizing a vehicle's performance is described. The method features the steps of: i) generating data representative of the vehicle's performance with at least one microcontroller disposed within the vehicle; ii) transferring the data through an OBD, OBD-II or equivalent electrical connector to a data collector/router that includes a microprocessor and an electrically connected wireless transmitter; iii) transmitting a data packet representing the data with the wireless transmitter over an airlink to a wireless communications system and then to a host computer; and iv) analyzing the data packet with the host computer to characterize the vehicle's performance.

36 Claims, 4 Drawing Sheets



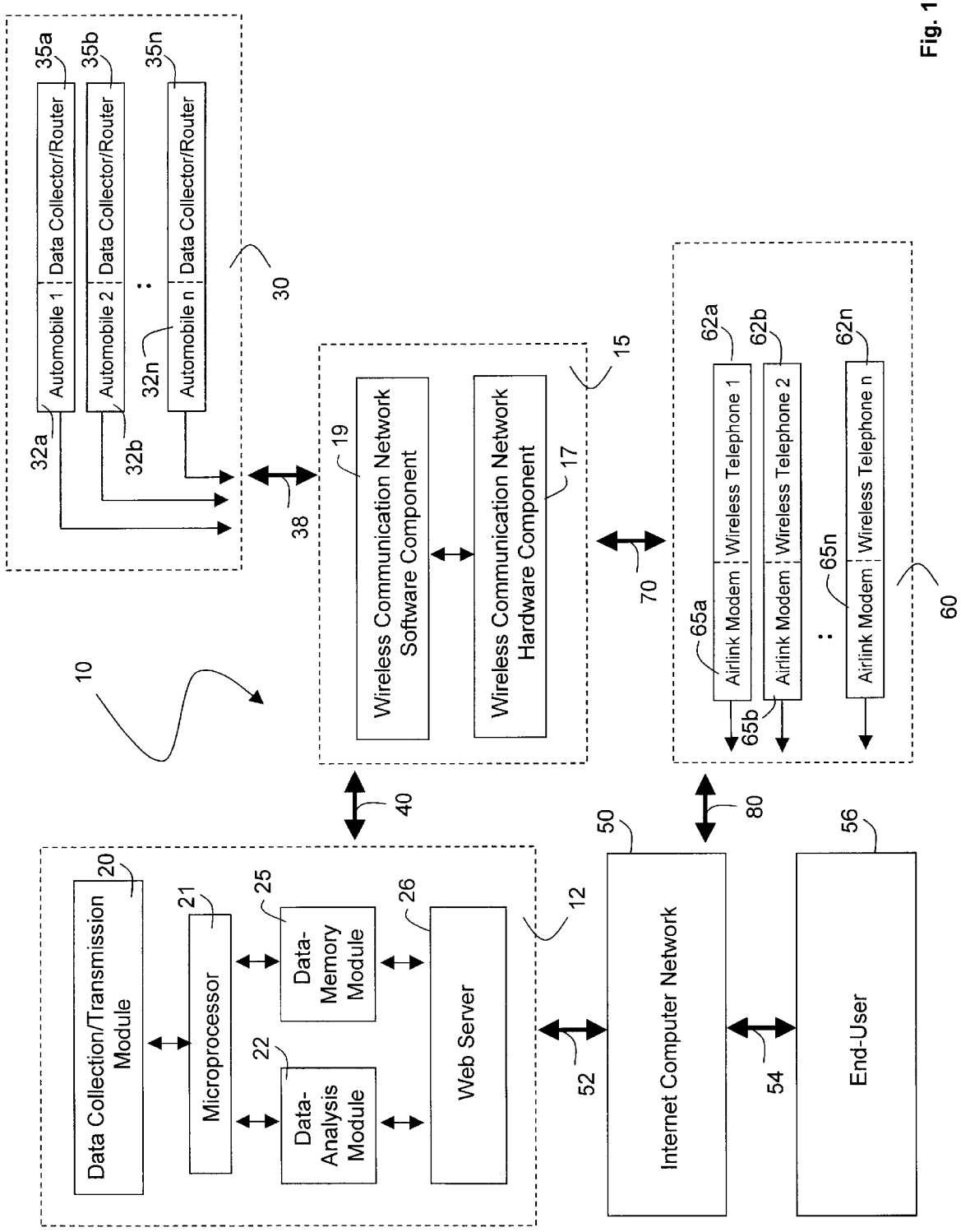

Automobile 1
Data Collector/Router
Automobile 2
Data Collector/Router
Automobile n
Data Collector/Router
35a
35b
35n
32a
32b
32n
30
38
10
Wireless Communication Network Software Component
Wireless Communication Network Hardware Component
19
17
15
70
Airlink Modem
Wireless Telephone 1
Airlink Modem
Wireless Telephone 2
Airlink Modem
Wireless Telephone n
65a
65b
65n
62a
62b
62n
60
40
80
Data Collection/Transmission Module
Microprocessor
Data-Analysis Module
Data-Memory Module
Web Server
20
21
22
25
26
12
52
54
Internet Computer Network
50
End-User
56

Fig. 1

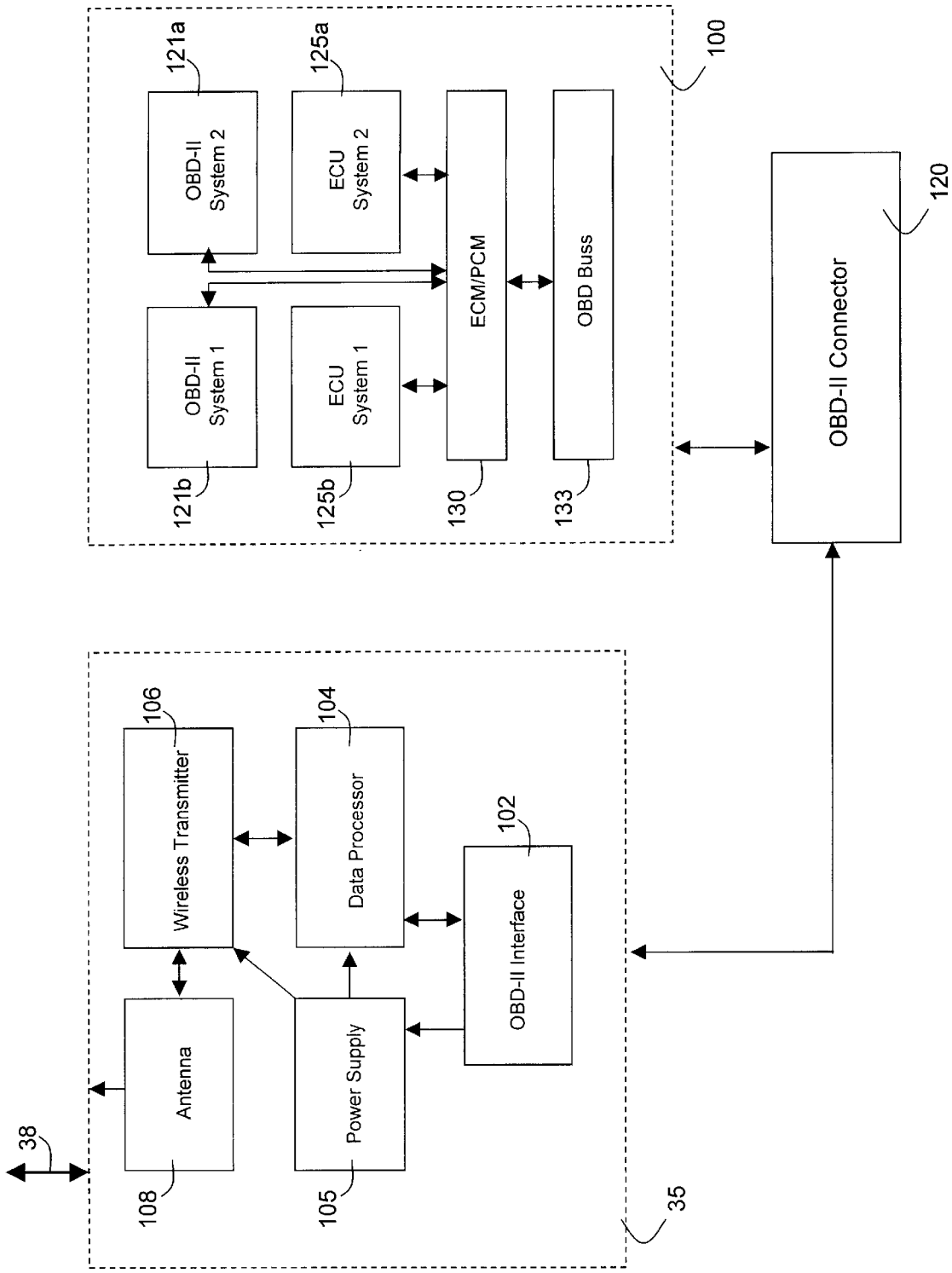

121a
OBD-II System 2
125a
ECU System 2
100
121b
OBD-II System 1
125b
ECU System 1
130
ECM/PCM
133
OBD Buss
120
OBD-II Connector
38
108
Antenna
106
Wireless Transmitter
105
Power Supply
104
Data Processor
102
OBD-II Interface
35

Fig. 2

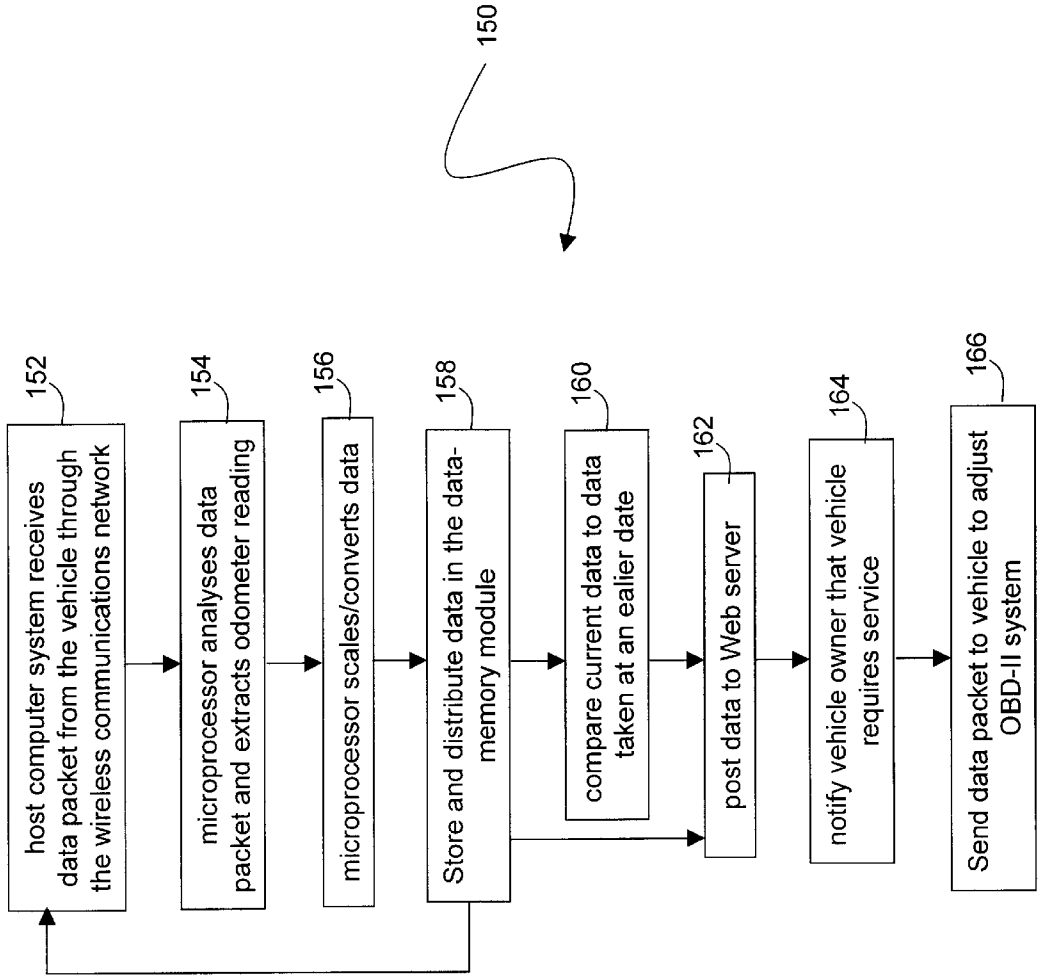

150
152
host computer system receives data packet from the vehicle through the wireless communications network
154
microprocessor analyses data packet and extracts odometer reading
156
microprocessor scales/converts data
158
Store and distribute data in the data-memory module
160
compare current data to data taken at an ealier date
162
post data to Web server
164
notify vehicle owner that vehicle requires service
166
Send data packet to vehicle to adjust OBD-II system

Fig. 3

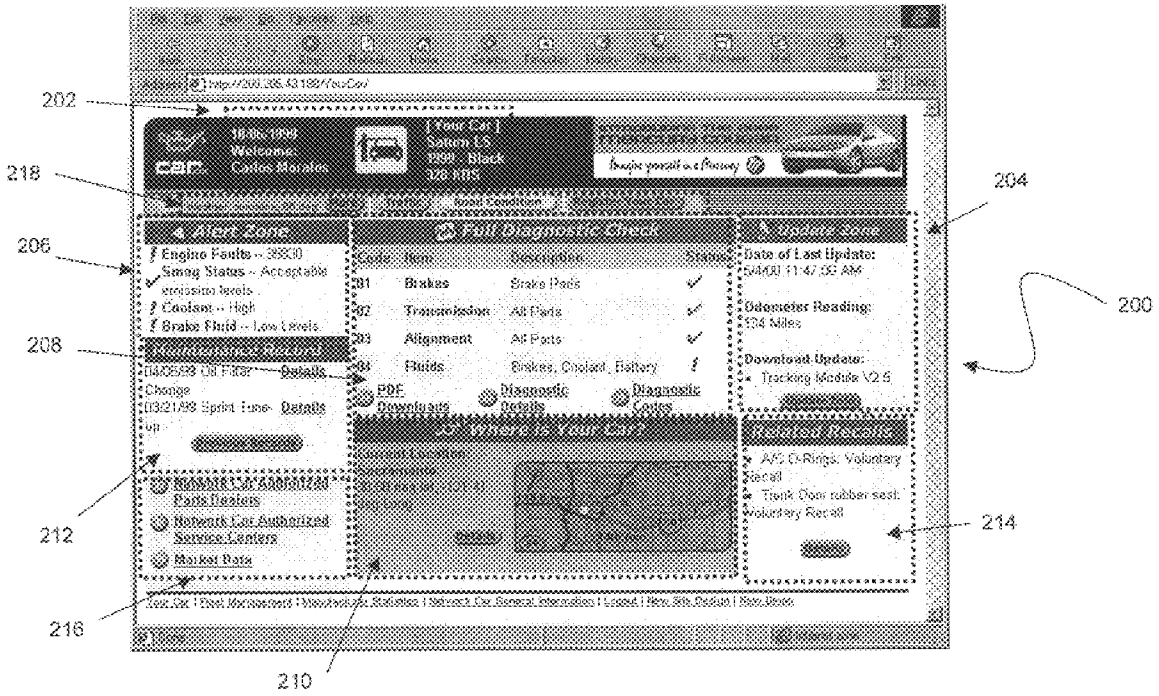

202
218
206
208
212
216
210
204
200
214
Engine Faults
Smog Status
Coolant
Brake Fluid
Brakes
Transmission
Alignment
Fluids
Date of Last Update:
Odometer Reading:
Download Update:
Market Parts

Fig. 4

WIRELESS DIAGNOSTIC SYSTEM AND METHOD FOR MONITORING VEHICLES

RELATED APPLICATION

Under 35 U.S.C. §119(e)(1), this application claims benefit of prior U.S. Provisional Applications No. 60/222,152, entitled "Wireless Diagnostic System for Characterizing a Vehicles Exhaust Emissions" filed Aug. 1, 2000; and No. 60/222,213, entitled "Wireless Diagnostic System for Characterizing One or More Vehicles' Mileage, Fuel Level, and Period of Operation" filed Aug. 1, 2000, both of which are incorporated herein by reference; and it claims benefit of prior U.S. Provisional Application No. 60/220,986 entitled "Wireless Diagnostic System for Vehicles" filed Jul. 25, 2000.

In addition, this application is related to the following U.S. Patent Applications that were filed on the same day as the present application: (1) U.S. Patent Application entitled "Wireless Diagnostic System for Characterizing a Vehicles Exhaust Emissions" with inventors Matthew J. Banet, Bruce Lightner, Diego Borrego, Chuck Myers, and Larkin H. Lowrey (U.S. Ser. No. 09/776,033); and (2) U.S. Patent Application entitled "Wireless Diagnostic System for Characterizing One or More Vehicles' Mileage, Fuel Level, and Period of Operation" with inventors Matthew J. Banet, Bruce Lightner, Diego Borrego, Chuck Myers, and Larkin H. Lowrey (U.S. Ser. No. 09/776,083), both of which are hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention relates generally to the use of wireless communications and diagnostic systems in automotive vehicles.

BACKGROUND OF THE INVENTION

The Environmental Protection Agency (EPA) requires vehicle manufacturers to install on-board diagnostics (OBD) for emission control on their light-duty automobiles and trucks beginning with model year 1996. OBD systems (e.g., computer, microcontrollers, and sensors) monitor the vehicle's emission control systems to detect any malfunction or deterioration that causes emissions to exceed EPA-mandated thresholds. Such a system, for example, is an oxygen sensor located in the vehicle's exhaust manifold and tailpipe.

The EPA requires that all information monitored or calculated by OBD systems is made available through a standardized, serial 16-cavity connector referred to as the ALDL (Assembly Line Diagnostic Link) or OBD connector. All physical and electrical characteristics of this connector are standard for all vehicles sold in the United States after 1996. The EPA also mandates that, when emission thresholds are exceeded, diagnostic information characterized by OBD systems must be stored in the vehicle's central computer so that it can be used during diagnosis and repair.

A second generation of OBD systems ("OBD-II" systems) monitors a wide range of data that indicate the performance of the host vehicle. For example, these data can be analyzed to infer the vehicle's emission performance. In addition to emissions, OBD-II systems monitor vehicle speed, mileage, engine temperature, and intake manifold pressure. OBD-II systems also query manufacturer-specific data, such as data relating to the vehicle's engine, transmission, brakes, alarm, entertainment systems. OBD-II systems also monitor codes called diagnostic trouble codes, or "DTCs", which indicate a mechanic or electrical problem with the vehicle. DTCs are

the codes that typically light a vehicle's 'service engine soon' light. In total, OBD-II systems typically access more than 300 segments of data relating to the performance and make of the host vehicle.

In addition to the OBD-II systems, most vehicles manufactured after 1996 have electronic control units (ECUs) that control internal electromechanical actuators. Examples include ECUs that control fuel-injector pulses, spark-plug timing, and anti-lock braking systems. Most ECUs transmit status and diagnostic information over a shared, standardized electronic buss in the vehicle. The buss effectively functions as an on-board computer network with many processors, each of which transmits and receives data. The primary computers in this network are the vehicle's electronic-control module (ECM) and power-control module (PCM). The ECM typically accesses computers and microcontrollers that monitor or control engine functions (e.g., the cruise-control module, spark controller, exhaust/gas recirculator). The PCM typically controls or monitors ECUs associated with the vehicle's power train (e.g., its engine, transmission, and braking systems).

When a vehicle is serviced, data from the standardized buss can be queried using external engine-diagnostic equipment (commonly called 'scan tools') that connect to the above-described 16-cavity electrical connector (called an OBD-II connector for vehicles made after 1996). The OBD-II connector is typically located under the vehicle's dashboard on the driver's side. Data transferred through the connector to the scan tool yields data that identify a status of the vehicle and whether or not a specific component of the vehicle has malfunctioned. This makes the service process more efficient and cost-effective.

Some manufacturers include complex electronic systems in their vehicles to access and analyze the above-described data. These systems are not connected through the OBD-II connector, but instead are wired directly to the vehicle's electronic system. This wiring process typically takes place when the vehicle is manufactured. In some cases these systems transmit data through a wireless network.

BRIEF SUMMARY OF THE INVENTION

It is an object of the present invention to address the limitations of the conventional engine-diagnostic systems discussed above. Specifically, it is an object of the invention to both access and send data over the ODB-II connector using a remote, wireless system that connects to the Internet using an airlink. The device used for accessing and transmitting the data is simple, low-cost, and easy-to-install.

In one aspect, the invention features a method and apparatus for remotely characterizing a vehicle's performance. The method features the steps of: i) generating data representative of the vehicle's performance with at least one microcontroller disposed within the vehicle; ii) transferring the data through an OBD, OBD-II or equivalent electrical connector to a data collector/router that includes a microprocessor and an electrically connected wireless transmitter; iii) transmitting a data packet representing the data with the wireless transmitter over an airlink, to a wireless communications system, and then to a host computer; and iv) analyzing the data packet with the host computer. Once analyzed, the data can be used to characterize the vehicle's performance, e.g. evaluate the vehicle's electrical and mechanical systems. The data can also be used for other purposes, such as for insurance-related issues, surveys, and vehicle tracking.

The terms 'microcontroller' and 'microprocessor' refer to standard electronic devices (e.g., programmable, silicon-

based devices) that can control and/or process data. For example, a sensor disposed in the vehicle (e.g., an oxygen sensor) would be a microcontroller. "Airlink" refers to a standard wireless connection between a transmitter and a receiver.

In the above-described method, steps i)–iv) can be performed at any time and with any frequency, depending on the diagnoses being performed. For a 'real-time' diagnoses of a vehicle's engine performance, for example, the steps may be performed at rapid time or mileage intervals (e.g., several times each minute, or every few miles). Alternatively, other diagnoses (e.g. a 'smog check' that includes inferring the concentrations of hydrocarbons, oxides of nitrogen, or carbon monoxide) may require the steps to be performed only once each year or after a large number of miles are driven. Steps i)–iii) (i.e. the 'generating', 'transferring', and 'transmitting' steps) may be performed in response to a signal sent from the host computer to the vehicle. Alternatively, the vehicle may be configured to automatically perform these steps at predetermined or random time intervals.

The generating step typically includes generating data encoded in a digital format using the vehicle's electronic control unit (ECM) and/or power control unit (PCM). The data, for example, describes the vehicle's mileage, exhaust emissions, engine performance, engine temperature, coolant temperature, intake-manifold pressure, engine-performance tuning parameters, alarm status, accelerometer status, cruise-control status, fuel-injector performance, spark-plug timing, and/or a status of an anti-lock braking system. The data can also be a DTC or related code. The analyzing step features extracting data from the transmitted data packet, and then storing the data in a computer memory or database.

Once stored, the data is processed in a variety of ways. For example, the processing can simply involve determining the vehicle's odometer reading, and then comparing this reading to a schedule that lists recommended, mileage-dependent service events (e.g., a 5000-mile tune-up). Other algorithms include those that compare current data with data collected at an earlier time to dynamically characterize the performance of the vehicle. In another example, the algorithms compare the data with a predetermined numerical value or collection of values. For example, the data can correspond to a level of the vehicle's exhaust emissions or mileage; these values can then be compared to predetermined values for the particular vehicle to characterize its performance. More complex processing can include, for example, analyzing the data with a mathematical algorithm to predict the electrical or mechanical performance of the vehicle or a failure of a particular component.

After the processing step, the method can also include the step of sending an electronic text, data, or voice message to a computer, cellular telephone, personal digital assistant or wireless device to alert the end-user of a potential problem. The results from the analysis can also be displayed on similar devices connected to the World-Wide Web or the Internet.

In another embodiment, the method additionally includes the step of sending a second data packet from the host computer system over an airlink to the wireless communications system and then to the vehicle's data collector/router. In this case, the second data packet is processed by the microprocessor in the data collector/router to generate a signal that is sent to at least one of the vehicle's microcontrollers. There, the signal is processed and used, for example to adjust a setting in the particular microcontroller. The signal can also be used to update or distribute new software or firmware configurations to one or more of the vehicle's microcontrollers. In still other embodiments, the signal can be used to make 'tailored' readings of the vehicle's diagnostic information, e.g. to perform complex diagnoses (sometimes called 'drilling down') and isolate malfunctioning components in the vehicle's mechanical or electrical systems.

In another aspect, the invention features a method for sending data to an electrical system in a vehicle. The method features the steps of: i) generating with a host computer a data packet that affects at least one microcontroller disposed within the electrical system of the vehicle; ii) transmitting the data packet from the host computer over an airlink to a wireless communications system and then to a data collector/router (containing a microprocessor and wireless transmitter similar to that described above) disposed in the vehicle; iii) receiving the data packet with the wireless transmitter and sending it to the microprocessor; iv) processing the data packet with the microprocessor to generate data; and v) transmitting the data through an OBD, OBD-II or equivalent electrical connector to the microcontroller disposed within the vehicle's electrical system.

The invention has many advantages. In particular, wireless transmission of a vehicle's diagnostic data makes it possible to remotely identify potential problems without bringing the vehicle to a conventional service center. For example, the system can be configured so that when a DTC is generated by a vehicle the code associated with it is automatically sent to the web sites of a service center and the vehicle owner. This way, the service center can diagnose the problem, order the required parts, and schedule the service before the vehicle owner actually brings in the vehicle for service. In certain situations, potential problems with the vehicle can be remotely predicted and addressed before they actually occur. Moreover, data from the vehicle can be queried, stored and analyzed frequently and in real-time (i.e., while the vehicle is actually in use) to provide a relatively comprehensive diagnosis that is not possible in a conventional service center.

The device used to access and transmit the vehicle's data is small, low-cost, and can be easily installed in nearly every vehicle with an OBD-II connector in a matter of minutes. It can also be easily transferred from one vehicle to another, or easily replaced if it malfunctions.

Communication with the vehicle's OBD buss can also be bi-directional, making it possible to actually repair certain problems remotely. This, of course, means that in some cases the vehicle's problem can be both diagnosed and repaired in a completely remote and unobtrusive manner.

Data transmitted from the vehicle can also be analyzed for purposes unrelated to mechanical or electrical problems. For example, the data can be collected and analyzed in real-time to characterize driving patterns (e.g. a vehicle's speed), automotive part reliability, and emission characteristics. Lessors and renters of vehicles can remotely track mileage for billing purposes. Smog and emission certifications can be easily done in a completely remote manner. Data can also be analyzed to determine the vehicle's approximate location as a safety or anti-theft measure.

Another advantage of the invention is that data transmitted from a particular vehicle over a wireless airlink can be accessed and analyzed through the Internet without the need for expensive diagnostic equipment. Software used for the analysis can be easily modified and updated, and then used by anyone with access to the Internet. This obviates the need

for vehicle service centers to upgrade their diagnostic equipment for next-generation vehicles. The resulting data, of course, have many uses for vehicle owners, surveyors of vehicle performance (e.g., J. D. Power), manufacturers of vehicles and related parts, and vehicle service centers.

Sophisticated analysis of the above-mentioned data yields information that benefits the consumer, vehicle and parts manufacturers, vehicle service centers, and the environment.

These and other advantages of the invention are described in the following detailed disclosure and in the claims.

BRIEF DESCRIPTION OF DRAWINGS

The features and advantages of the present invention can be understood by reference to the following detailed description taken with the drawings, in which:

FIG. **1** is a schematic drawing of a wireless diagnostic system in wireless contact with a system of vehicles and the Internet;

FIG. **2** is a schematic drawing of a data collector/router used in each of the vehicles of FIG. **1**;

FIG. **3** is a flow chart describing analysis of data transmitted by the data collector/router by the host computer of FIG. **1**; and

FIG. **4** is a screen capture of a page from the Web server of FIG. **1**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows a wireless diagnostic system **10** that communicates with a collection of vehicles **30** using a host computer system **12** and a standard wireless communications system **15**. The wireless communications system **15** is, e.g., a conventional wireless telephone or paging system (e.g., Bell South's 'Mobitex' System). Each vehicle **32***a*, **32***b*, **32***n* in the collection of vehicles **30** features a data collector/router **35***a*, **35***b*, **35***n* that queries data generated by each vehicle's ECU and OBD-II systems through an OBD buss. After the query, each data collector/router **35***a*, **35***b*, **35***n* receives data from the host vehicle **32***a*, **32***b*, **32***n* and sends it as a data packet over a wireless airlink **38** to the wireless communication system **15**. The wireless communication system **15** features a standard hardware component **19** (e.g. a system of transmission 'base stations', computers, and switching and routing hardware) and software component **17** (e.g., a paging or cellular network) that relay the data packet through a digital line **40** to the host computer system **12**.

A data collection/transmission module **20** (e.g., a digital transmission line) in the host computer system **12** receives the data packet and then routes it to a microprocessor **21**. The microprocessor controls a data-analysis module **22** (e.g., hardware and software for statistical analysis) that processes the data packet, and a data-memory module **25** (e.g., a computer memory or database) that stores it. A web server **26** receives the processed data from the data-analysis **22** and data-memory modules **25** and makes it available to an Internet computer network **50** through a first network connection **52**. An end-user **56** accesses the data on the web server **26** through a second network connection **54** using the Internet computer network **50**.

Data packets from each data collector/router **35***a*, **35***b*, **35***n* can also be accessed directly over an airlink **70** by wireless telephones **62***a*, **62***b*, **62***n* in a wireless telephone network **60**. In this case each wireless telephone **62***a*, **62***b*, **62***n* has an airlink modem **65***a*, **65***b*, **65***n* that allows the data packet to be accessed directly. Alternatively, using the airlink modem **65***a*, **65***b*, **65***n*, the wireless telephones **62***a*, **62***b*, **62***n* can access processed data from the web server **26**, provided they have the appropriate software (e.g., web-browsing capabilities). In this case, the web server **26** formats the data in a manner suitable to wireless browsing (e.g. wireless access protocol).

The host computer system **12** typically works bi-directionally, i.e. it can both send data to and receive data from the data collector/routers **35***a*, **35***b*, **35***n* present on each vehicle **32***a*, **32***b*, **32***n*. For example, following a query, the host computer system **12** receives a data packet from a particular data collector/router. The system typically runs a real-time operating system (e.g., Windows NT® or Unix®) that manages multiple software programs conducting different functions (e.g. data processing and storage).

Data is typically sent from the host vehicle **32***a*, **32***b*, **32***n* to each data collector/router **35***a*, **35***b*, **35***n* at a predetermined time interval (e.g. a random or periodic time interval) that is programmed in either the data collector/router or the actual vehicle. For example, data can be sent on a daily basis. Alternatively, data can be queried in response to a signal sent from the host computer system **12** to the data collector/routers **35***a*, **35***b*, **35***n* present on each vehicle **32***a*, **32***b*, **32***n*.

Depending on the make and model of the vehicle, the data packet can contain hundreds of datum that describe, e.g.: i) basic properties of the power train (e.g., emission levels, fuel-system status, engine temperature, speed and odometer readings, anti-lock brake status, RPMs, fuel and intake manifold pressure); and ii) manufacturer-specific information (e.g., status of the door locks, airbags, and entertainment center). In total, for most vehicles there are typically more than 300 datum that can be included in the data packet.

Certain vehicle functions can also be controlled by sending a data packet to the vehicle. Data in the data packet can adjust, for example, settings in the ECUs and OBD-II sensors, certain engine properties, and indicator lights on the vehicle's dashboard. They can also be used to open door locks and reconfigure the vehicle's entertainment system.

In addition, data packets routed through the wireless communications system **15** can be analyzed to determine the vehicle's approximate location. This can be done with relatively low accuracy (within a few miles) by simply recording the location of a specific cellular tower in the hardware component **17** of the wireless communications system **15** that routes the data packet to the host computer system **12**. Recording the location of multiple base stations within range of the vehicle, and then analyzing these data using conventional algorithms (e.g., triangulation), increases the accuracy to which the vehicle's location is determined.

FIG. **2** shows a data collector/router **35** in electrical contact with a vehicle's OBD/ECU system **100**. The two systems connect through a conventional OBD-II connector **120** typically located under the vehicle's dashboard. The data collector/router **35** is contained in a small, portable housing that plugs directly into the connector **120** and can be easily installed and replaced.

The connector **120** has a serial, 16-cavity layout, with specific electrical connections in separate cavities supplying data and electrical power from the OBD/ECU system **100**. The connector electrically and mechanically matches an OBD-II interface **102** in the data collector/router **35**. Although the OBD-II connector **120** has a standard mechanical interface, data transmitted through it may have a format and pass through cavities that depend on the

vehicle's make and model. For example, Ford and General Motors vehicles use an OBD data format called J1850; data in this format pass through cavities **2** and **10**. Chrysler and most European and Asian manufacturers use a data format called ISO 9141-2 and pass data through cavities **7** and **15**. In a third format, called J2284, data is passed through cavities **6** and **14**.

The connector **120** also passes battery power (cavity **16**), automobile chassis ground (cavity **4**), and signal ground (cavity **5**) from the OBD/ECU system **100** through the OBD-II interface **102** to the data collector/router **35**. Using these connections, a power supply **105** receives the battery power, regulates it, and in turn drives a data processor **104** and wireless transmitter **106** within the data collector/router **35**.

Once received, data is passed to the data processor **104** (e.g., a microprocessor) that processes and formats it to form a data packet. As an example, a data packet and specifically formatted for Bell South's wireless 900 MHz mobitex MPAK system is described in Table below. Actual data describing the host vehicle is contained in the 516-byte data area described in Table 1.

TABLE 1

description of Mobitex MPAK data packet

Bytes	General Description	
3	source MAN (unique 24-Bit modem number)	
3	destination MAN (unique 24-Bit modem number)	
1	when sending:	Bit 0 = use mailbox Bit 1 = return positive acknowledgment Bit 2 = use address list Bits 3–7 = 0
	when receiving:	Bit 4 = may be ignored Bits 5–7 = traffic state
1	MPAK type	
0 or 22	address list	
0 to 512	data payload	

Once properly formatted as described in Table 1, the data packet is passed from the data processor **104** to the wireless transmitter **106**. The transmitter **106** transmits the data packet through a conventional wireless antenna **108** over an airlink **38** to a wireless communications system (**15**) shown in FIG. **1**. The data processor **104** formats the data packet according to the wireless communications system that transmits it.

Once transmitted, the data packet propagates through the wireless communication software and hardware components (**17** and **19** in FIG. **1**) of the communication network (e.g., the Mobitex network). Typically in this case the data packet is routed to a 'point of presence' or 'POP' in the network, where it is then transferred over a digital line (e.g., **40** in FIG. **1**) to the host computer system.

The data area described in Table 1 contains data generated by the vehicle's OBD/ECU system **100**. As described above, this system **100** functions effectively as an on-board computer network that generates, transmits, and receives data. For simplicity, the system **100** in FIG. **2** contains two OBD-II systems **121***a*, **121***b* and two ECU systems **125***a*, **125***b;* it is analogous to more complex OBD-II and ECU systems employed in actual vehicles. The OBD-II systems **121***a*, **121***b* are microcontrollers that monitor the various vehicle-related properties described above. The ECU systems **125***a*, **125***b* receive and send data to electromechanical actuators that control, e.g., fuel-injector pulses, spark-plug timing, and anti-lock braking systems.

The OBD-II systems **121***a*, **121***b* and ECU systems **125***a*, **125***b* are controlled by the vehicle's ECM/PCM **130**. In some cases, the ECM/PCM **130** receives data from these systems and routes it over a shared electronic OBD buss **133**. Alternatively, after receiving the data the ECM/PCM **130** converts it to "fail" or "malfunction" codes that are then routed over the shared electronic buss **133**. In both cases, the OBD buss serially transmits data to the data collector/router **35** through the electrically connected OBD connector **120**.

Once collected and sent to the host computer system (**12** in FIG. **1**), the data packet can be analyzed in a variety of different ways. As an example, FIG. **3** shows a flow chart describing one method **150** of how data is analyzed and then made available to end-users through the Internet. A wide number of different data-analysis methods are possible; the one shown in FIG. **3** was chosen because of its simplicity.

In the data-analysis method **150**, the host computer system receives a data packet from the vehicle through the wireless communications network (step **152**). The data packet has a format shown, e.g., in Table 1 above, and contains a wide range of information that characterizes the vehicle's performance. Once received, the packet is analyzed and an odometer reading (e.g., mileage) from the vehicle is extracted (step **154**). If necessary, the microprocessor then scales the odometer reading (e.g., converts kilometers to miles) or converts the format used in the data packet (e.g., a manufacturer-specific format) to one that is easily recognized by the end-user (step **156**). At this point the odometer reading and other data within the data packet are distributed and stored in the data-memory module (e.g. a database) of the host computer system (step **158**). Some data may be simply disregarded during this step. This portion (steps **152**, **154**, **156**, and **158**) of the method may be repeated at this point to generate additional data.

All the data (e.g. the vehicle's mileage collected at different time or mileage intervals) can be posted directly on a Web page on the Web server (step **162**) where it is accessible by the end-user through the Internet. The data can also be analyzed further. For example, a current odometer reading can be compared to one recorded at an earlier date (step **160**) to determine how many miles the vehicle has traveled since its last oil change. If this value exceeds that recommended for the particular vehicle, the host computer system can notify the user through electronic mail that the vehicle requires service (step **164**). The method **150** can also be used to remotely adjust settings in the vehicle's OBD-II systems. For example, at this point the host computer system could send a data packet to the vehicle to reset the trip odometer to a new value (step **166**).

FIG. **4** shows a sample Web page **200** from a Web server that displays data processed using a method similar to that shown in FIG. **3**. Access to Web page is typically password-protected, thereby only allowing end-users with the correct password to access data for a particular vehicle.

The Web page **200** features a region **202** that describes the owner of the vehicle and its make and model. The page **200** also has a region **204** that describes the time, date, and odometer readings registered at its last update. Data describing vehicle problems (e.g., engine faults, coolant and brake fluid levels, emission status) that may require immediate attention are displayed in region **206**. Data used to diagnose the overall condition of the vehicle (e.g., brake and transmission status, wheel alignment) are displayed in region **208**. More data relating to these properties can be obtained by clicking the appropriate buttons ("Diagnostic Details", "Diagnostic Codes") in this region. The page **200** also

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includes a region **210** that provides the approximate location of the vehicle. As described above, the vehicle's location is determined by recording the location of one or more base stations used to send the latest data packet through the wireless communications system. The page also includes a region **212** that features data describing the general history and maintenance of the vehicle. A related region **214** describes parts for the particular vehicle that have been recently recalled. A region **216** describes the locations of parts dealers and local service stations for the particular vehicle, while the region **218** provides access to features that may affect travel, such as weather, traffic, road conditions, and the status of the vehicle's registration.

Other embodiments are within the scope of the invention. For example, the components used in the data collector/router (particularly the wireless transmitter) may be optimized for different types of wireless communications systems. These systems include wireless telephone and paging systems, Bluetooth®, and similar systems. Similarly, the format of the data packet may also be adjusted for transmission over different types of networks. In general, any components in the data collector/router, and any format of the data packet, can be used to accomplish the general method of the invention.

Likewise, a wide range of mathematical algorithms can be used to analyze data once it is extracted from the data packets. These algorithms range from the relatively simple (e.g., lessors and renters determining the mileage on a vehicle for billing purposes) to the complex (e.g., predictive engine diagnoses using 'data mining' techniques). Data analysis may be used to characterize an individual vehicle as described above, or a collection of vehicles. Algorithms used to characterize a collection of vehicles can be used, for example, for remote vehicle or parts surveys, to characterize emission performance in specific geographic locations, or to characterize traffic.

Other embodiments of the invention include algorithms for analyzing data to characterize vehicle accidents and driving patterns for insurance purposes; algorithms for determining driving patterns for use-based leasing; and algorithms for recording vehicle use and driving patterns for tax purposes. In general, any algorithm that processes data collected with the above-described method is within the scope of the invention.

Similarly, the temporal or mileage frequency at which data is collected can be adjusted to diagnose specific types of problems. For example, characterization of certain types of vehicle performance indicators, such as emissions, may need to be monitored relatively frequently. Other properties, such as mileage and fluid levels, may only need to be monitored every few days, or in some cases just a few times each year.

Once the data is analyzed, the Web page used to display the data can take many different forms. Different Web pages may be designed and accessed depending on the end-user. For example, individual users may have access to Web pages for their particular vehicle. Conversely, vehicle service providers (e.g. providers that change oil or certify a vehicle's emissions) may have access to Web pages that contain data (e.g., mileage and emissions data) from a wide range of vehicles. These data, for example, can be sorted and analyzed depending on vehicle make, model, and geographic location. Web pages may also be formatted using standard wireless access protocols (WAP) so that they can be accessed using wireless devices such as cellular telephones, personal digital assistants (PDAs), and related devices.

In other embodiments, additional hardware can be added to the in-vehicle unit. For example, hardware for global-positioning systems (GPS) may be added so that the location of the vehicle can be monitored along with its data.

In other embodiments, data from the data collector/router in the vehicle can be analyzed and used for: remote billing/payment of tolls; remote smog and emissions checks; remote payment of parking/valet services; remote control of the vehicle (e.g., in response to theft or traffic/registration violations); and general survey information.

Still other embodiments are within the scope of the following claims.

What is claimed is:

1. A method for characterizing a vehicle's performance, comprising the steps of:

retrieving data representative of the vehicle's performance through the vehicle's OBD or OBD-II connector according to a communication protocol at a predetermined time interval with a data collector/router comprising:

i) an electrical connector that connects to the OBD or OBD-II connector;

ii) a microprocessor configured to retrieve and transmit data at the predetermined time interval, and

iii) a wireless transmitter in electrical contact with the microprocessor;

wirelessly transmitting the data with the wireless transmitter to a wireless communications system and then to a host computer; and

analyzing the data with the host computer.

2. The method of claim **1**, wherein the data is serially transferred through an OBD-II connector to the data collector/router.

3. The method of claim **2**, wherein the protocol used to transfer data through the OBD-II connector is J1850, ISO 9141-2, J2284, or equivalents thereof.

4. The method of claim **1**, wherein the generating step further comprises generating data encoded in a digital format using an electronic control unit and/or power control unit.

5. The method of claim **4**, wherein the generating step further comprises generating data that describes at least one of the vehicle's mileage, exhaust emissions, engine performance, engine temperature, coolant temperature, intake-manifold pressure, vehicle-identification number, engine-performance tuning parameters, alarm status, accelerometer status, fuel-injector performance, spark-plug timing, and a status of an anti-lock braking system.

6. The method of claim **1**, wherein the analyzing step further comprises extracting data from the data packet corresponding to a specific property of the vehicle and storing the data in a computer memory or database.

7. The method of claim **6**, wherein the analyzing step further comprises processing the data stored in the computer memory or database with an algorithm.

8. The method of claim **7**, wherein the processing further comprises analyzing the data with a mathematical algorithm to characterize or predict the electrical or mechanical performance of the vehicle.

9. The method of claim **7**, wherein the processing further comprises comparing the data with data collected at an earlier time to characterize or predict the performance of the vehicle.

10. The method of claim **7**, wherein the processing further comprises comparing the data with a predetermined numerical value or collection of values to characterize the performance of the vehicle.

11. The method of claim 7, wherein the data corresponds to a level of exhaust emissions for the vehicle, and the processing comprises comparing the level of exhaust emissions to a predetermined value for the particular vehicle to characterize the performance of the vehicle.

12. The method of claim 7, wherein the data corresponds to a mileage for the vehicle, and the processing comprises comparing the mileage to a predetermined value for the particular vehicle to characterize the performance of the vehicle.

13. The method of claim 1, further comprising sending an electronic text, data, or voice message to a computer, cellular telephone, or wireless device after the data is analyzed.

14. The method of claim 1, further comprising displaying results from the analysis on a computer, cellular telephone, or wireless device connected to the World-Wide Web or the Internet.

15. The method of claim 1, wherein the results are displayed on a page on the World-Wide Web or the Internet.

16. The method of claim 1, wherein the method further comprises the step of wirelessly sending a second data packet from the host computer system to the wireless communications system and then to the data collector/router disposed in the vehicle.

17. The method of claim 16, wherein the second data packet is processed by the microprocessor in the data collector/router to generate a signal, and the signal is sent to at least one microcontroller disposed within the vehicle.

18. The method of claim 17, wherein the signal is processed by the microcontroller and used to adjust it.

19. A system for characterizing a vehicle's performance comprising:

a data collector/router comprising:

an electrical connector configured to connect to the vehicle's OBD or OBD-II connector;

a microprocessor in electrical contact with the electrical connector, the microprocessor configured to retrieve data generated by the vehicle at a predetermined time interval; and

a wireless transmitter configured to receive the data from the microprocessor and wirelessly transmit it to a network;

a first computer system comprising a processor configured to receive the data from the network; and

a second computer system configured to analyze the data.

20. The system of claim 19, wherein the data collector/router is configured to serially transfer data through an OBD-II connector to the data collector/router.

21. The method of claim 19, wherein the data collector/router is configured to transfer data using a J1850, ISO 9141-2, or J2284 protocol, or an equivalent thereof.

22. The system of claim 19, wherein the processor in the host computer system is configured to analyze the data with a mathematical algorithm to predict or characterize the performance of the vehicle.

23. The system of claim 19, wherein the processor in the host computer system is configured to compare the data with other data from a data packet collected from the vehicle at an earlier time to characterize the performance of the vehicle.

24. The system of claim 19, wherein the processor in the host computer system is configured to compare the data with a predetermined numerical value or collection of values to characterize the performance of the vehicle.

25. The system of claim 19, wherein the data corresponds to a level of exhaust emissions for the vehicle, and the processor in the host computer system is configured to compare the level of exhaust emissions to a predetermined value for the particular vehicle to characterize the performance of the vehicle.

26. The system of claim 25, wherein the data is analyzed to infer the concentration of hydrocarbons, oxide of nitride, or carbon monoxide emitted from the vehicle.

27. The system of claim 19, wherein the data corresponds to a mileage for the vehicle, and the processor in the host computer system is configured to compare the mileage to a predetermined value for the particular vehicle to characterize the performance of the vehicle.

28. A system for characterizing a vehicle's performance comprising a data collector/router comprising:

an electrical connector configured to connect through the vehicle's OBD or OBD-II connector;

a microprocessor in electrical contact with the electrical connector, the microprocessor configured to retrieve data generated by the vehicle at a predetermined time interval; and

a wireless transmitter configured to receive the data from the microprocessor and wirelessly transmit it to a network.

29. The system of claim 28, wherein the microprocessor is additionally configured to serially transfer data through the OBD, OBD-II or equivalent electrical connector.

30. The method of claim 29, wherein the microprocessor is configured to transfer data using a J1850, ISO 9141-2, or J2284 protocol, or an equivalent thereof.

31. A system for characterizing a vehicle's performance comprising a data collector/router comprising:

an on-board diagnostic connector configured to connect to a serial connector located in the vehicle's interior;

a microprocessor in electrical contact with the on-board diagnostic connector, the microprocessor configured to retrieve data generated by the vehicle at a predetermined time interval;

a wireless transmitter integrated in the data collector/router configured to receive the data from the microprocessor and wirelessly transmit it to a network; and

a housing containing the microprocessor and the wireless transmitter.

32. The system of claim 31, wherein the serial electronic connector is located underneath the vehicle's steering column.

33. The system of claim 31, wherein the microprocessor is additionally configured to serially transfer data through the serial connector.

34. The method of claim 33, wherein the microprocessor is configured to transfer data using a J1850, ISO 9141-2, or J2284 protocol, or an equivalent thereof.

35. A method for sending data to an electrical system in a vehicle, comprising the steps of:

generating with a host computer data that affects at least one microcontroller disposed within the electrical system of the vehicle;

wirelessly transmitting the data from the host computer to a wireless communications system and then to a data collector/router disposed in the vehicle, the data collector/router comprising:

i) an electrical connector that connects to an OBD or OBD-II connector and comprises electrical connections for multiple vehicle models;

ii) a microprocessor, and

iii) a wireless transmitter in electrical contact with the microprocessor;

receiving the data with the wireless transmitter;

sending the data from the wireless transmitter to the microprocessor;

processing the data with the microprocessor to generate processed data; and

transmitting the processed data through the electrical connector to the microcontroller disposed within the vehicle's electrical system.

36. A method for characterizing a vehicle's performance, comprising the steps of:

retrieving data representative of the vehicle's performance through an OBD or OBD-II connector at a predetermined time interval with a data collector/router comprising:

i) an electrical connector that connects to the OBD or OBD-II connector and comprises electrical connections for multiple vehicle models;

ii) a microprocessor, and

iii) a wireless transmitter in electrical contact with the microprocessor;

generating data representative of the vehicle's location with a global positioning system disposed within the vehicle;

wirelessly transmitting a first set of data representative of the vehicle's performance with the wireless transmitter to a wireless communications system and then to a host computer;

wirelessly transmitting a second set of data representative of the vehicle's location with the wireless transmitter to a wireless communications system and then to a host computer;

analyzing the first and second sets of data with the host computer to generate analyzed data; and

displaying the analyzed data on one or more web pages accessible on the internet.

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US006636790C1

(12) EX PARTE REEXAMINATION CERTIFICATE (10010th)

United States Patent

Lightner et al.

(10) Number: US 6,636,790 C1

(45) Certificate Issued: Jan. 15, 2014

(54) **WIRELESS DIAGNOSTIC SYSTEM AND METHOD FOR MONITORING VEHICLES**

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Reexamination Request:
No. 90/011,306, Dec. 3, 2010

Reexamination Certificate for:

Patent No.:	**6,636,790**
Issued:	**Oct. 21, 2003**
Appl. No.:	**09/776,106**
Filed:	**Feb. 1, 2001**

Related U.S. Application Data

(60) Provisional application No. 60/222,152, filed on Aug. 1, 2000, provisional application No. 60/222,213, filed on Aug. 1, 2000, provisional application No. 60/220,986, filed on Jul. 25, 2000.

(51) **Int. Cl.**
G01M 15/10 (2006.01)
G01M 15/04 (2006.01)

(52) **U.S. Cl.**
USPC **701/31.5**; 701/31.4; 701/34.4

(58) **Field of Classification Search**
None
See application file for complete search history.

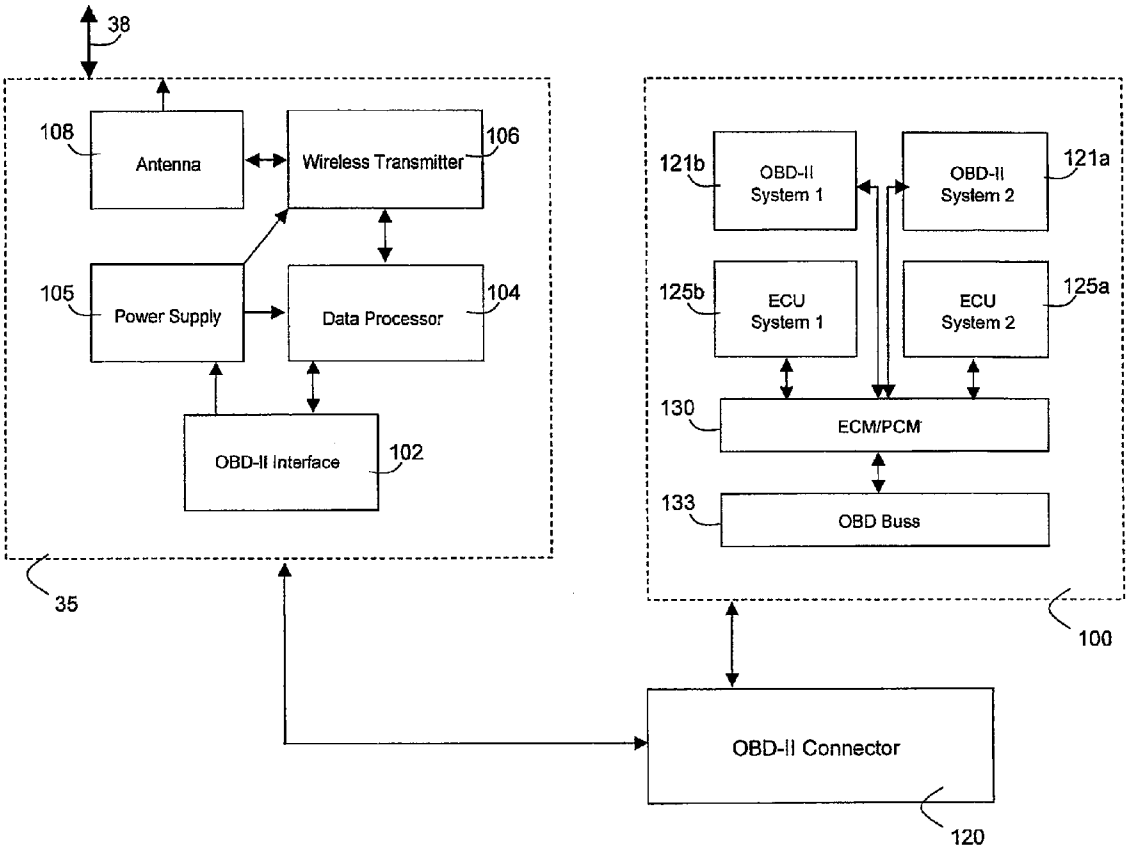
(56) **References Cited**

To view the complete listing of prior art documents cited during the proceeding for Reexamination Control Number 90/011,306, please refer to the USPTO's public Patent Application Information Retrieval (PAIR) system under the Display References tab.

Primary Examiner — Deandra Hughes

(57) **ABSTRACT**

A method and apparatus for remotely characterizing a vehicle's performance is described. The method features the steps of: i) generating data representative of the vehicle's performance with at least one microcontroller disposed within the vehicle; ii) transferring the data through an OBD, OBD-II or equivalent electrical connector to a data collector/router that includes a microprocessor and an electrically connected wireless transmitter; iii) transmitting a data packet representing the data with the wireless transmitter over an airlink to a wireless communications system and then to a host computer; and iv) analyzing the data packet with the host computer to characterize the vehicle's performance.



EX PARTE REEXAMINATION CERTIFICATE ISSUED UNDER 35 U.S.C. 307

THE PATENT IS HEREBY AMENDED AS INDICATED BELOW.

AS A RESULT OF REEXAMINATION, IT HAS BEEN DETERMINED THAT:

Claims **1**, **6-19**, **22-28**, **31** and **36** are cancelled.

Claims **2-5**, **20-21**, **29-30** and **32-35** were not reexamined.

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