US 20120239243A1

(19) **United States**

(12) **Patent Application Publication**

Medwin et al.

(10) **Pub. No.: US 2012/0239243 A1**

(43) **Pub. Date: Sep. 20, 2012**

(54) **SYSTEM FOR ACCESSING INFORMATION FOR MAINTAINING AND REPAIRING INDUSTRIAL VEHICLES**

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(21) Appl. No.: **13/487,836**

(22) Filed: **Jun. 4, 2012**

Related U.S. Application Data

(62) Division of application No. 12/423,877, filed on Apr. 15, 2009.

(60) Provisional application No. 61/046,247, filed on Apr. 18, 2008.

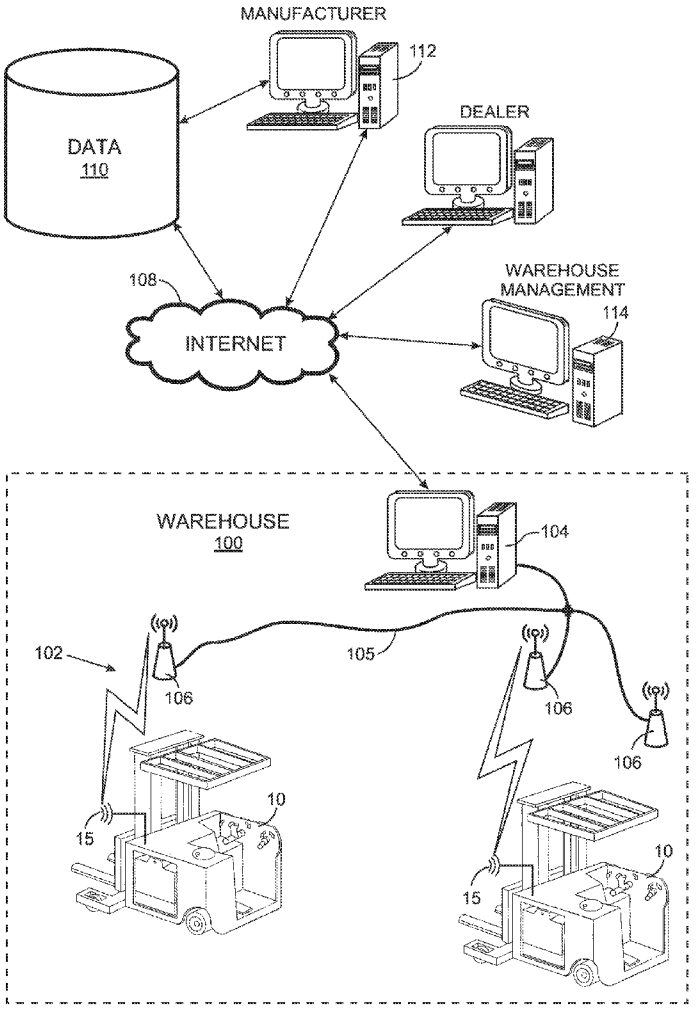
Publication Classification

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

(52) **U.S. Cl.** **701/31.6**

(57) **ABSTRACT**

A database, contained in a computer system onboard the industrial vehicle, stores repair information and as built information about the specific optional features incorporated into that particular industrial vehicle. For example, the database contains one or more of a repair manual, a parts manual, an operating manual, and service bulletins. Upon occurrence of an operating problem, the industrial vehicle generates a fault code designating the operating problem. The computer system uses the fault code to access the database and obtain the as built information and the repair information associated with the operating problem. The repair information may describe a process for diagnosing a cause of the operating problem, a process for identifying a defective component, and a process for replacing the defective component. The computer system also may place an order for a replacement component.



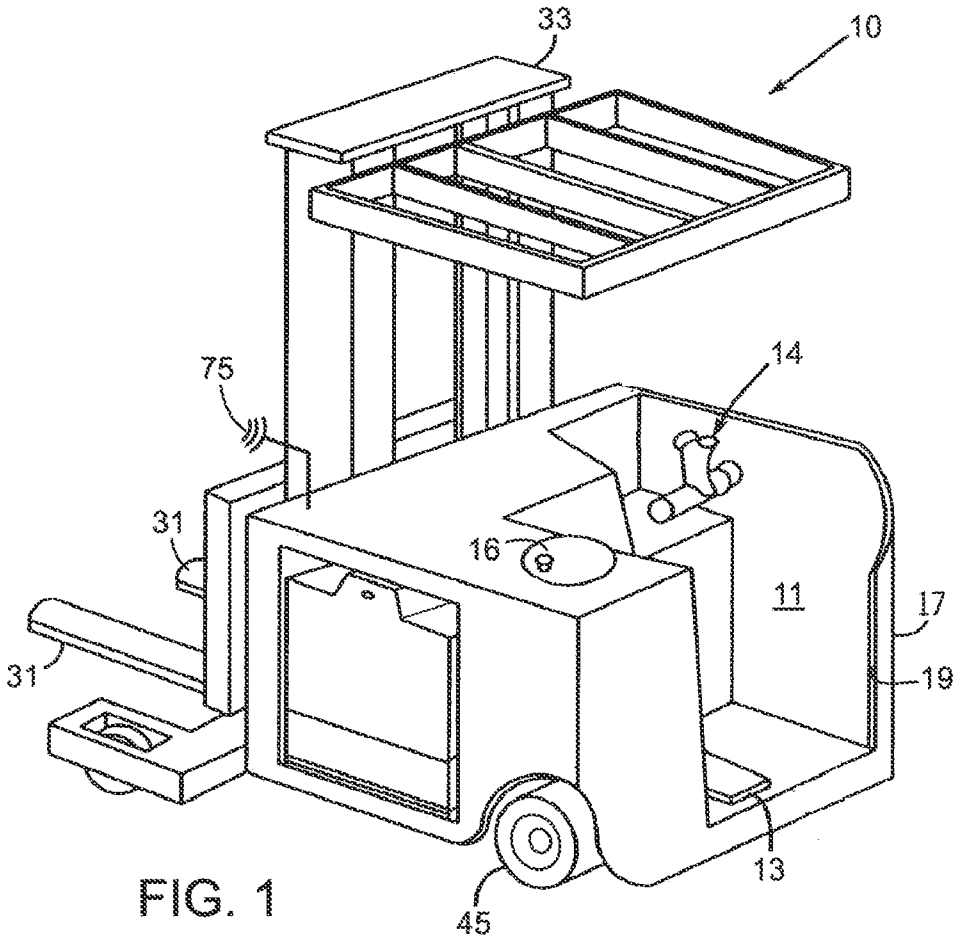


FIG. 1

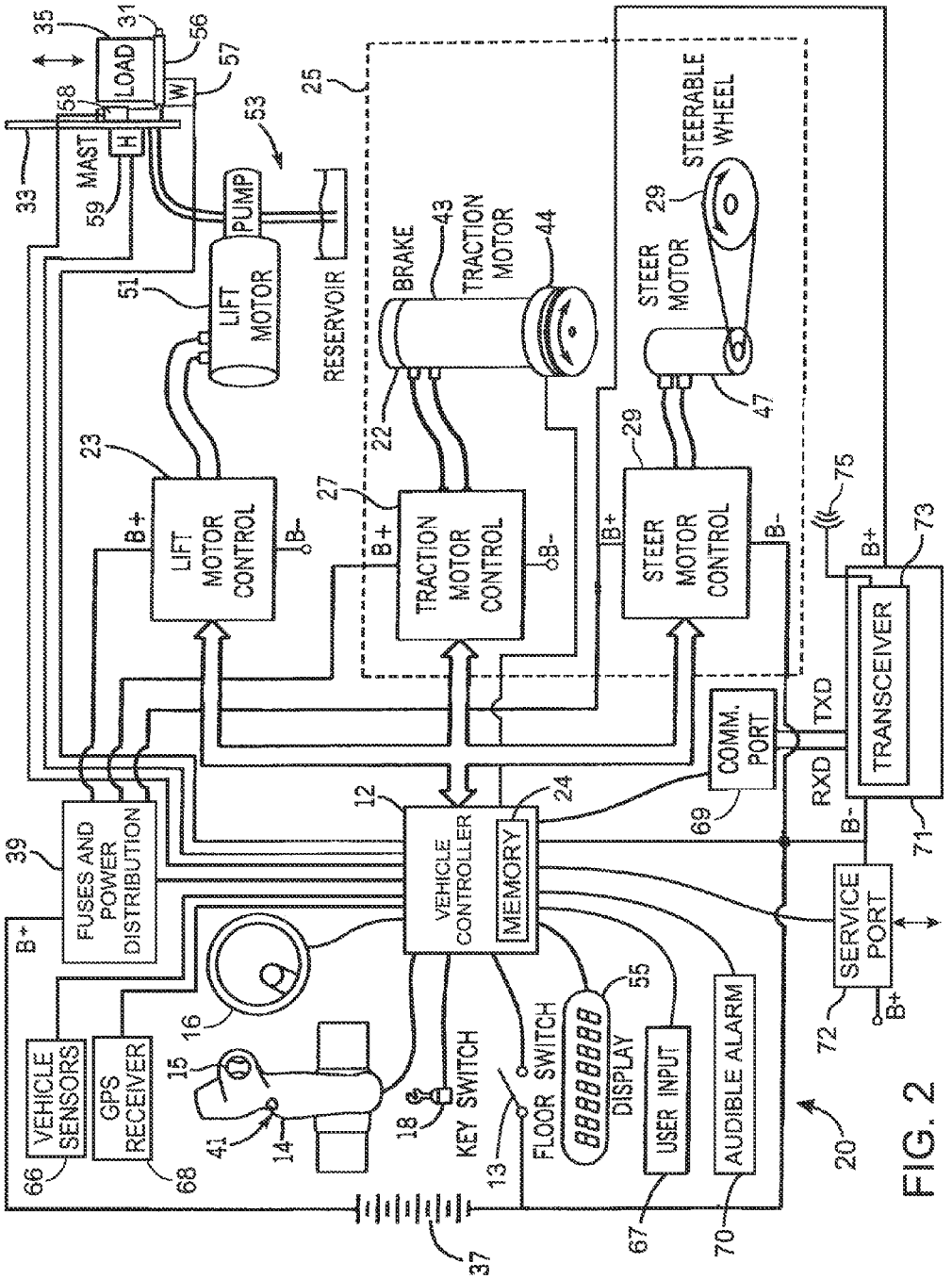

LOAD
MAST
PUMP
LIFT MOTOR
RESERVOIR
BRAKE
TRACTION MOTOR
STEER MOTOR
STEERABLE WHEEL
LIFT MOTOR CONTROL
TRACTION MOTOR CONTROL
STEER MOTOR CONTROL
FUSES AND POWER DISTRIBUTION
VEHICLE CONTROLLER
MEMORY
COMM. PORT
TRANSCEIVER
SERVICE PORT
VEHICLE SENSORS
GPS RECEIVER
KEY SWITCH
FLOOR SWITCH
DISPLAY
USER INPUT
AUDIBLE ALARM
TXD
RXD
B+
B-

FIG. 2

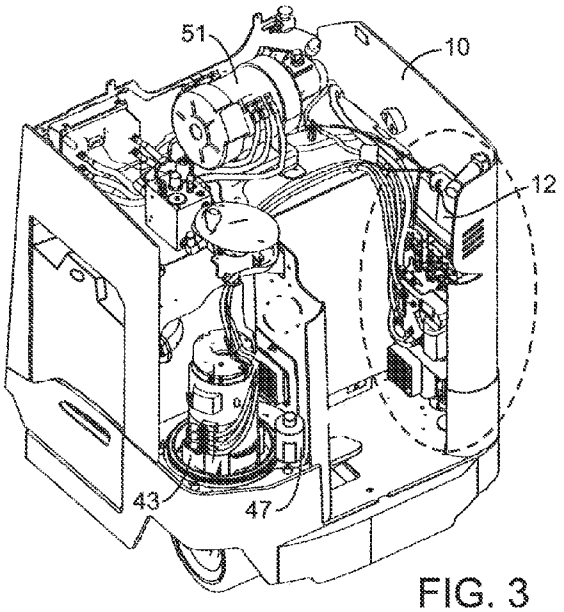


FIG. 3

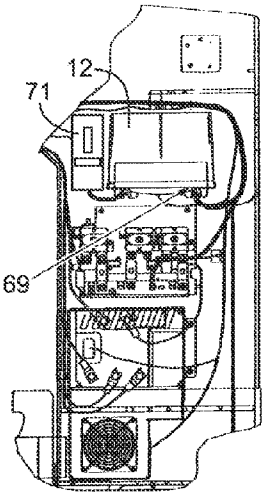


FIG. 4

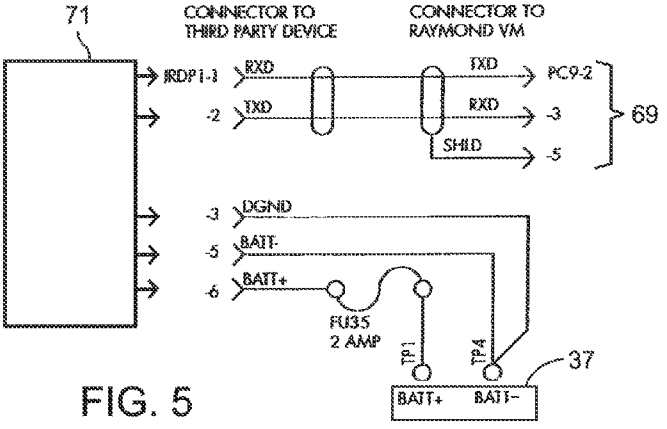


FIG. 5

FIG. 6

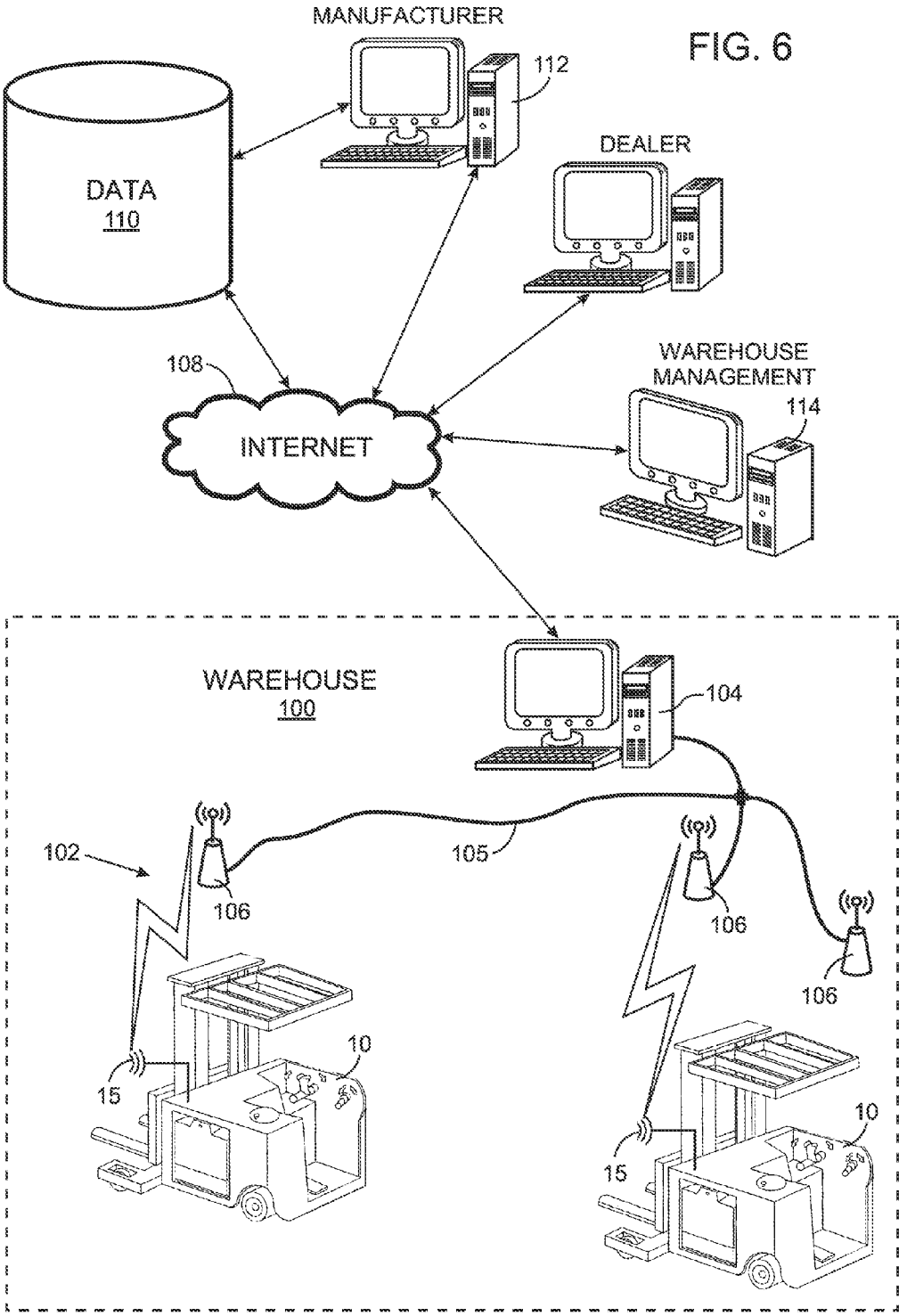

MANUFACTURER
112
DATA
110
DEALER
108
INTERNET
WAREHOUSE
MANAGEMENT
114
WAREHOUSE
100
104
102
105
106
106
106
10
15
10
15

FIG. 7

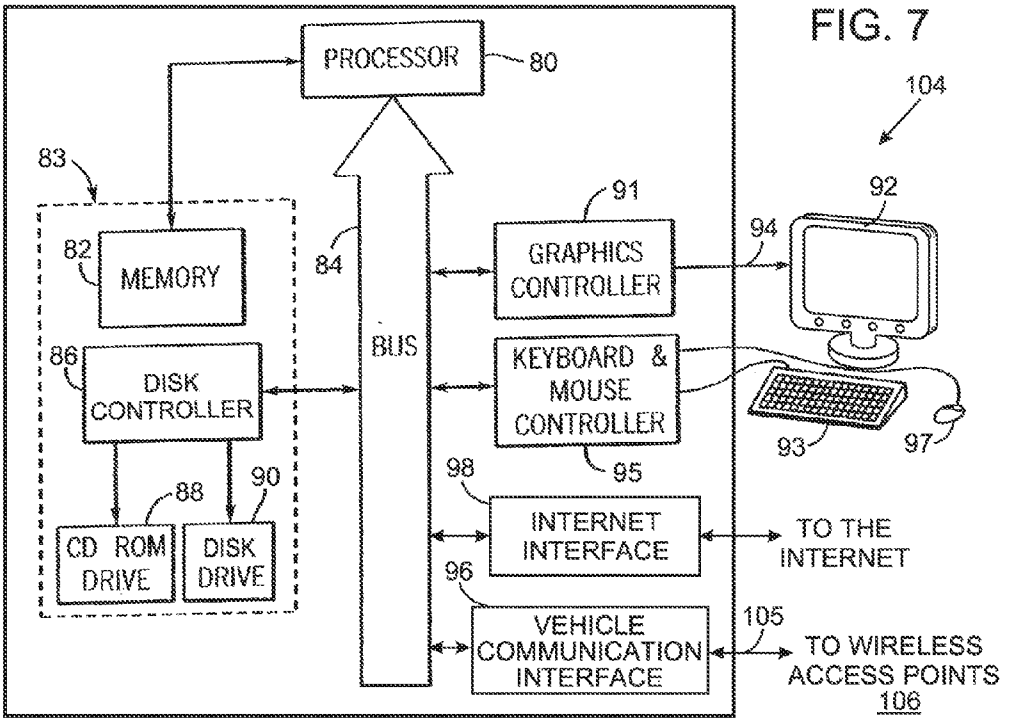

PROCESSOR
80
104
83
91
92
82
MEMORY
84
GRAPHICS CONTROLLER
94
BUS
86
DISK CONTROLLER
KEYBOARD & MOUSE CONTROLLER
93
97
95
98
88
90
CD ROM DRIVE
DISK DRIVE
INTERNET INTERFACE
TO THE INTERNET
96
VEHICLE COMMUNICATION INTERFACE
105
TO WIRELESS ACCESS POINTS
106

FIG. 8

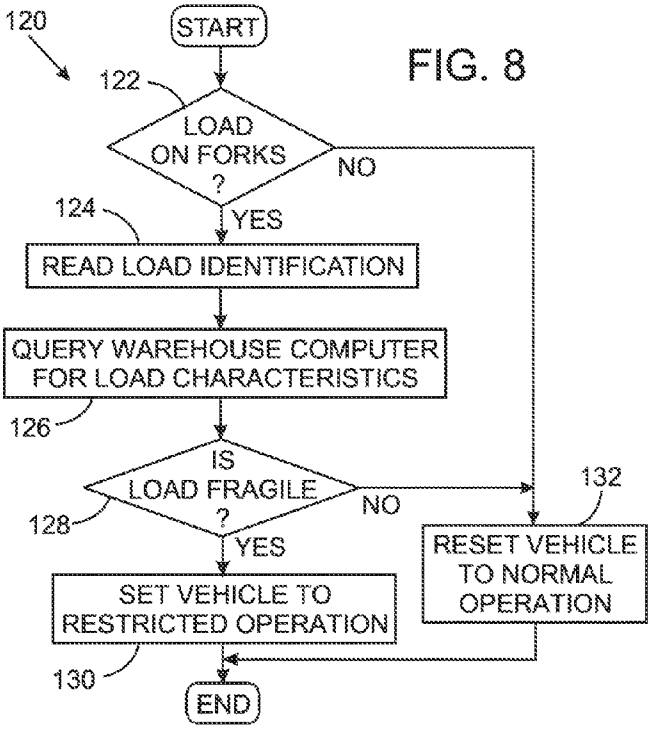
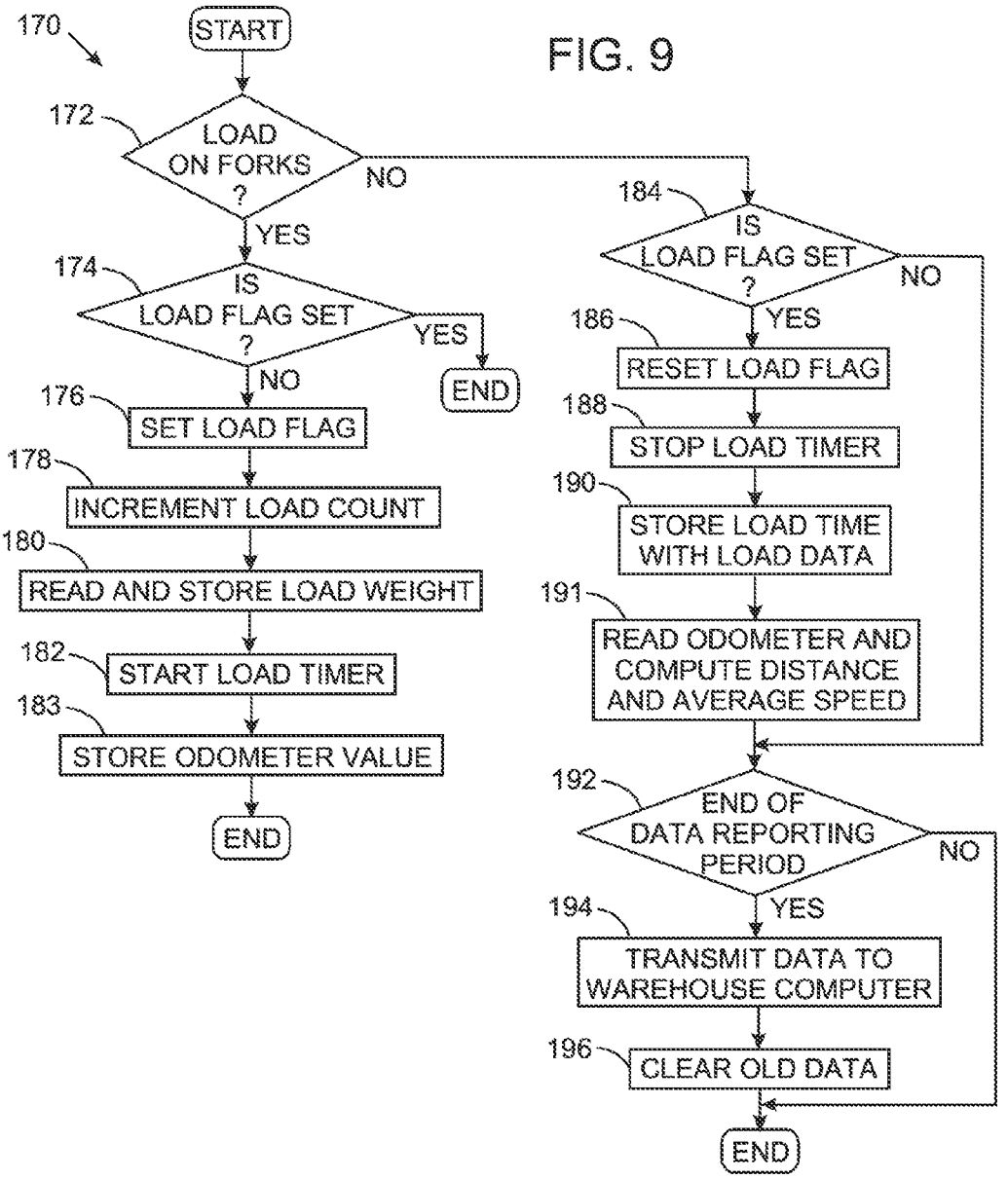

120
START
122
LOAD ON FORKS ?
NO
YES
124
READ LOAD IDENTIFICATION
QUERY WAREHOUSE COMPUTER FOR LOAD CHARACTERISTICS
126
IS LOAD FRAGILE ?
128
NO
YES
132
RESET VEHICLE TO NORMAL OPERATION
SET VEHICLE TO RESTRICTED OPERATION
130
END

FIG. 9


170
START
172
LOAD ON FORKS ?
NO
YES
174
IS LOAD FLAG SET ?
YES
END
NO
176
SET LOAD FLAG
178
INCREMENT LOAD COUNT
180
READ AND STORE LOAD WEIGHT
182
START LOAD TIMER
183
STORE ODOMETER VALUE
END
184
IS LOAD FLAG SET ?
NO
YES
186
RESET LOAD FLAG
188
STOP LOAD TIMER
190
STORE LOAD TIME WITH LOAD DATA
191
READ ODOMETER AND COMPUTE DISTANCE AND AVERAGE SPEED
192
END OF DATA REPORTING PERIOD
NO
YES
194
TRANSMIT DATA TO WAREHOUSE COMPUTER
196
CLEAR OLD DATA
END

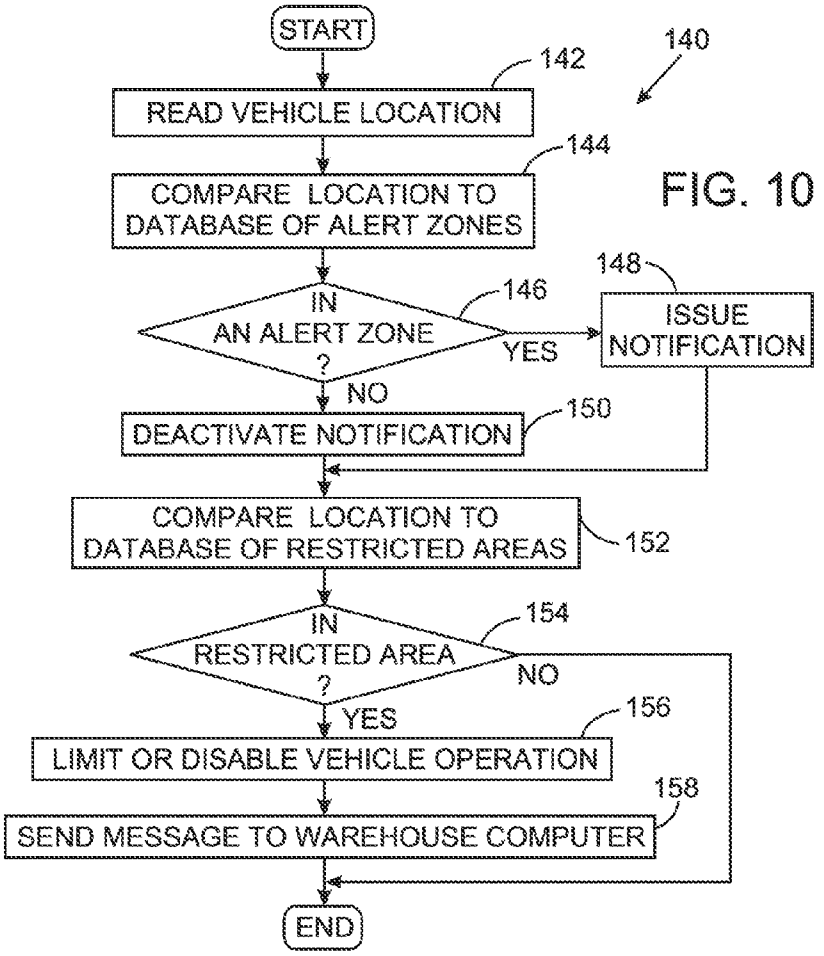

START
140
142
READ VEHICLE LOCATION
144
COMPARE LOCATION TO DATABASE OF ALERT ZONES
148
146
IN AN ALERT ZONE ?
YES
ISSUE NOTIFICATION
NO
150
DEACTIVATE NOTIFICATION
COMPARE LOCATION TO DATABASE OF RESTRICTED AREAS
152
154
IN RESTRICTED AREA ?
NO
YES
156
LIMIT OR DISABLE VEHICLE OPERATION
158
SEND MESSAGE TO WAREHOUSE COMPUTER
END

FIG. 10

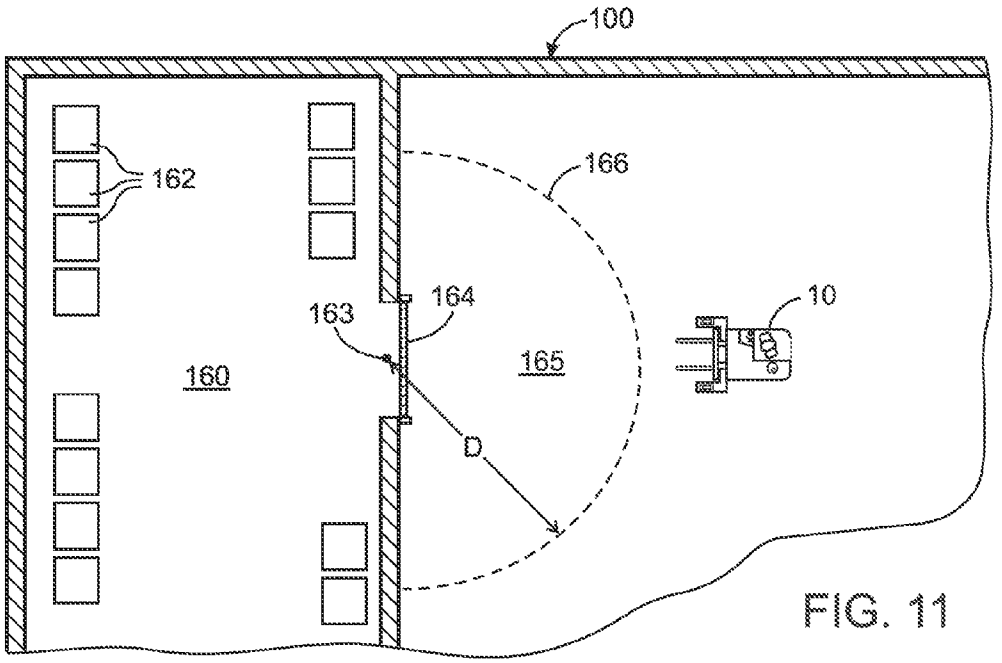

100
162
166
164
163
10
160
165
D

FIG. 11

SYSTEM FOR ACCESSING INFORMATION FOR MAINTAINING AND REPAIRING INDUSTRIAL VEHICLES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a division of U.S. patent application Ser. No. 12/423,877 filed on Apr. 15, 2009, and claims benefit of U.S. provisional patent application No. 61/046,247 filed on Apr. 18, 2008.

STATEMENT CONCERNING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

BACKGROUND OF THE INVENTION

[0003] 1. Field of the Invention

[0004] The present invention relates to industrial vehicles, such as lift trucks; and more particularly to a system for sensing performance characteristics of an industrial vehicle and using those characteristics to manage the operation of the vehicle.

[0005] 2. Description of the Related Art

[0006] Industrial vehicles of various types, including material handling vehicles, are used to move items inside a factory, a warehouse, a freight transfer station, a store, or other type of facility. In order to effectively and efficiently operate a warehouse, for example, it is important to ensure that the equipment and employees are as productive as possible. Recent studies, in fact, have indicated that 70 percent to 80 percent of the cost of owning and operating an industrial vehicle is attributed to labor. For a warehouse to compete on the global level, continually improving operator productivity is vital to reducing costs. To meet these goals, warehouse management systems are frequently employed to control inventory, ensure proper maintenance of equipment, and to monitor operator and equipment efficiency. In these warehouse management systems, a centralized computer system monitors inventory flow, use of the industrial vehicle, vehicle maintenance status, and operator performance.

[0007] To provide these functions, data is gathered from each industrial vehicle. In order to gather the data, wiring harnesses and sensors typically are added to the industrial vehicle after manufacture, often after delivery to the warehouse. These wiring harnesses connect sensors and other devices to a dedicated onboard computer, and provide a number of connection points within the vehicle. Because of the large number of connection points, these add-on systems are susceptible to failure. In addition, the post-manufacture sensors provide only limited information and can be inaccurate. Thus a more optimized system for monitoring a vehicle's performance and operation is desired.

[0008] Safe operation of an industrial vehicle requires, operator training and skill, good lift truck maintenance and a safe workplace with appropriately configured lift trucks. Fragile loads sometimes fall off and are damaged when the operator drives the industrial vehicle too fast for conditions in the warehouse. Also certain warehouse environments, such as cold storage areas and areas with potentially explosive atmospheres, require special industrial vehicles that are designed to operate in such environments. For example, Standard UL 583, promulgated by the Underwriters Laboratories of Northbrook, Ill., U.S.A., specifies "spark proof" characteristics for a Type EE industrial vehicle for use in areas where flammable materials are stored. A potential hazard exists when a vehicle that is not Type EE rated is used in such storage areas.

[0009] As industrial vehicles have gotten more sophisticated, with computerized controls for example, maintenance practices have had to change accordingly. A particular lift truck model may have numerous optional features that a user may choose to have added during manufacture. Typically a dealer dispatches a service technician to the warehouse or factory to perform maintenance and repairs on an industrial vehicle. The service technician needs to know exactly which application specific options and features have been incorporated into the vehicle being serviced and may need access to any of several service manuals associated with the particular vehicle model and the installed options and features. This means that in order to service a complete product line of industrial vehicles and different models which have been manufactured over many years, the service technician has to be able to access a sizable library of manuals and supplementary materials when in a warehouse or factory.

SUMMARY OF THE INVENTION

[0010] An industrial vehicle has a computerized controller that receives data from a plurality of sensors which monitor different operating parameters of the vehicle. The industrial vehicle has components that communicate wirelessly via a bidirectional warehouse communication system with a computer system at a facility, such as a warehouse or a factory, where the vehicle operates. This enables data regarding the operating parameters to be sent to the computer system and enables the industrial vehicle to receive data and commands from the computer system. Additionally, the warehouse communication system is connectable through a network, such as the Internet, to remote computers, such as at the headquarters of the company that operates the facility and at the manufacturer of the vehicle.

[0011] The controller on the industrial vehicle in communication with other computers enables implementation of various functions which control operation of the vehicle. One function limits vehicle operation to assist in protecting fragile loads from being damaged by a careless operator. The control system on the vehicle reads an indicator on a load being transported by the industrial vehicle and determines from that indicator whether the load requires delicate handling. If that is the case, operation of the industrial vehicle is limited to provide such delicate handling. For example, the speed and/or rate of acceleration of the vehicle may be limited to lower than normal levels.

[0012] In different embodiments, reading the indicator on a load employs either a radio frequency identification tag reader, a bar code reader, or a device that utilizes a communication protocol defined by IEEE standard 1902.1 promulgated by The Institute of Electrical and Electronics Engineers, Inc., New York, N.Y., U.S.A.

[0013] Another function accumulates data regarding operation of the industrial vehicle to transport loads and analyzes that data to evaluate the vehicle performance. Here, a sensor detects when a load is being transported, and the controller onboard the industrial vehicle counts each load, thereby compiling load data. Additional types of data, such as for example, the weight of each load and the time that each load is being transported, also may be detected and added to the load data.

[0014] The controller responds to a given event by wirelessly transmitting the load data via a communication system to a computer system. For example, the controller may tabulate the load data every hour or every work shift, at the conclusion of which, the load data is transmitted to the computer system at the facility in which the vehicle operates.

[0015] The computer system transforms the load data into performance data denoting operational efficiency of the industrial vehicle. For example, the load data from one industrial vehicle is compared to similar data from other industrial vehicles at the facility or at a plurality of facilities. Such caparisons provide an efficiency evaluation of the performance of one vehicle or one operator.

[0016] In another case, the location of an industrial vehicle at a facility is detected, such as by using the global positioning satellite system or signals from a wireless communication system. At least one restricted area is defined at the facility. The location information is employed to determine when the industrial vehicle is within the restricted area, in which event operation of that vehicle is limited. For example, vehicle operation is disabled upon entering the restricted area.

[0017] In another aspect of this method, an alert area also is defined at the facility, such as in front of an entrance to the restricted area. When the location of the industrial vehicle is determined to be within the alert area, a notification is issued, for example to remind the vehicle operator of the proper operating guidelines.

[0018] Another function involves operating the industrial vehicle to utilize battery power efficiently. The battery is recharged when necessary by electricity from a utility company, which charges a first rate for electricity delivered during a first period of a day and charges a higher second rate for electricity delivered during a second period of the day. Operation of the industrial vehicle during the second period is limited to prolong battery life. For example, the maximum speed of travel is limited to lesser than normal at that time. Thus when the battery is required to be recharged, that recharging likely will occur during the first period of a day when a lower electric rate is in effect.

[0019] Servicing the industrial vehicle is facilitated by a process in which vehicle repair information is stored in a database implemented by a computer system. Upon occurrence of an operating problem, the industrial vehicle generates a fault code designating the operating problem. The fault code is used to access the database and obtain the repair information associated with the operating problem.

[0020] In one embodiment, the repair information describes a process for diagnosing the cause of the operating problem and identifying components which require replacement. Thereafter, other repair information is accessed which describes a process for replacing the component of the industrial vehicle which caused the operating problem.

[0021] These and other aspects of the invention will become apparent from the following description. In the description, reference is made to the accompanying drawings which form a part hereof, and in which there is shown a preferred embodiment of the invention. Such embodiment does not necessarily represent the full scope of the invention and reference is made therefore, to the claims herein for interpreting the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] FIG. **1** is a perspective view of an industrial vehicle including a system that provides wireless communications between a vehicle controller and a warehouse computer system in accordance with the present invention;

[0023] FIG. **2** is a block diagram of a control system of the industrial vehicle;

[0024] FIG. **3** is a back view of the industrial vehicle with a housing removed to illustrate connection of wireless communication transceiver to the industrial vehicle;

[0025] FIG. **4** is an enlarged section of FIG. **3**, that is indicated by a dashed oval, illustrating connections to a terminal strip for coupling the wireless communication transceiver to a wiring harness in the industrial vehicle;

[0026] FIG. **5** is a circuit diagram of the wiring harness;

[0027] FIG. **6** depicts an exemplary vehicle fleet management system in which industrial vehicles in a warehouse communicate via a network with a central computer in the warehouse that is linked to a remote database to which other computers have access;

[0028] FIG. **7** is a block diagram of the centralized computer in the warehouse;

[0029] FIG. **8** is a flowchart of a software routine that is executed by the control system of the industrial vehicle to manage operation while transporting fragile loads;

[0030] FIG. **9** is a flowchart of a software routine that enables the industrial vehicle to accumulate data about the loads that are transported;

[0031] FIG. **10** is a flowchart of a software routine that is executed by the control system of the industrial vehicle to prevent operation in restricted areas; and

[0032] FIG. **11** is a floor plan of part of the warehouse with an area to which access is restricted to only certain types of industrial vehicles.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0033] The present invention relates to the operation of an industrial vehicle. Although the invention is being described in the context of a stand-up counterbalanced lift truck used at a warehouse, the inventive concepts are applicable to other types of industrial vehicles, and specifically material handling vehicles, and their use in a variety of facilities, such as a factories, a warehouses, freight transfer stations, and stores, for example.

[0034] With initial reference to FIG. **1**, an industrial vehicle **10**, specifically a lift truck, includes an operator compartment **11** with an opening **19** for entry and exit by the operator. Associated with the operator compartment **11** are a control handle **14**, a floor switch **13**, and steering wheel **16**. An antenna **75** for wireless communications with an external warehousing system is coupled to the industrial vehicle **10** and is, as described more fully below, connected to an internal vehicle controller **12** (FIG. **2**) to provide bidirectional communications with a warehousing system. Although the industrial vehicle **10** which is shown by way of example as a standing, fore-aft stance operator configuration reach truck, it will be apparent to those of skill in the art that the present invention is not limited to vehicles of this type, and can also be provided in other types of industrial vehicle configurations including, without limitation, material handling vehicles, pallet trucks, lift trucks, orderpickers, sideloaders, stacker/retrieval machines, reach trucks, swing reach trucks, tow tractor, counterbalanced fork lift vehicles, and other industrial trucks. Furthermore, even though the present inventive con-

cepts are being described in the context of a battery powered vehicle, they apply equally well to vehicles with internal combustion engines.

[0035] Referring now to FIG. **2**, a block diagram of a control system **20** for a typical industrial vehicle **10** in which the present invention can be provided is illustrated. The control system **20** comprises a vehicle controller **12** which is a microcomputer based device that includes memory **24** and input/output circuits. The input/output circuits receive operator input signals from the operator control handle **14**, the steering wheel **16**, a key switch **18**, and the floor switch **13**; and provide command signals to each of a lift motor control **23** and a drive system **25** including both a traction motor control **27** and a steer motor control **29**. The drive system **25** provides a motive force for driving the industrial vehicle **10** in a selected direction, while the lift motor control **23** drives load carrying forks **31** along a mast **33** to raise or lower a load **35**, as described below. The industrial vehicle **10** and vehicle controller **12** are powered by one or more batteries **37** that are electrically coupled to the vehicle controller, drive system **25**, steer motor control **29**, and lift motor control **23** through a bank of fuses or circuit breakers **39**.

[0036] As noted above, the operator inputs include a key switch **18**, floor switch **13**, steering wheel **16**, and an operator control handle **14**. The key switch **18** is activated to apply power to the vehicle controller **12**, thereby enabling the industrial vehicle **10**. The floor switch **13** provides a signal to the vehicle controller **12** for operating the brake **22** to implement a deadman braking function that disables motion of the vehicle unless the floor switch is activated by the operator.

[0037] Rotation of the operator control handle **14** in a vertical plane provides a travel request signal to the vehicle controller **12** that indicates a travel direction and speed for the industrial vehicle **10**. A four-way switch **15** located on the top of the handle **14** provides a tilt up/down function when activated in the forward and back directions and a side shift right and left function when activated to the right and left directions. A plurality of control actuators **41** located on the handle **14** direct a number of additional functions, and can include, for example, a reach pushbutton, a retract pushbutton, and a horn pushbutton as well as a potentiometer providing a lift function. A number of other vehicle functions also can be provided depending on the construction and intended use of the industrial vehicle **10**.

[0038] The traction motor control **27** drives one or more traction motors **43** which is connected to a propulsion wheel **45** to provide motive force to the industrial vehicle. The speed and direction of the traction motor **43** and the associated propulsion wheel are designated by the operator via the operator control handle **14**, and are monitored and controlled through feedback derived from a rotation sensor **44**. The rotation sensor **44** can be an encoder or motion sensor coupled to the traction motor **43** and the signal therefrom is used to measure the distance that the vehicle travels. The rotation sensor signal is used to increment a software implemented odometer on the vehicle. The propulsion wheel **45** is also connected to friction brake **22** through the traction motor **43**, to provide both a service and parking brake function for the industrial vehicle **10**. The friction brake **22** can be spring-activated so that it defaults to a "brake-on" state, such that the floor switch **13** and associated brake **22** therefore provide the deadman braking function. The operator must provide a signal indicating that the deadman brake is to be released to drive the industrial vehicle, here provided by the floor switch **13**, as described above. The traction motor **43** is typically an electric motor, and the associated friction brakes **22** can be either electrically operated or hydraulically operated devices. Although one friction brake **22**, traction motor **43**, and propulsion wheel **45** are shown, the industrial vehicle **10** typically includes a plurality of these elements.

[0039] The steer motor control **29** is connected to drive a steer motor **47** and associated steerable wheel **49** in a direction selected by the operator by rotating the steering wheel **16**, described above. The direction of rotation of the steerable wheel **49** determines the direction that the industrial vehicle **10** travels.

[0040] The lift motor control **23** sends command signals to control a lift motor **51** which is connected to a hydraulic circuit **53** that form a lift assembly for raising and lowering the forks **31** along the mast **33**, depending on the direction selected at the control handle **14**. In some applications, the mast **33** can be a telescoping mast, in which case the hydraulic circuit also raises and lowers the mast. As shown here, a height sensor **59** is provided in the mast control system to provide a signal to the vehicle controller **12** indicating the height of the mast **33**. The height sensor **59** can be, for example, an encoder, a flow sensor in the hydraulic system, a light beam, or other types of sensors. Similarly, a weight sensor **57** is provided on the forks **31**. The weight sensor **57** can be, for example, a load cell, strain gauge, light beam or pressure sensor in the lift system and provides a signal to the vehicle controller **12** that indicates whether a load is on the forks, and a weight of the load. A load sensor **58** is mounted on the mast to obtain an identification of the goods being transported. The load sensor **58**, may be, for example, a radio frequency identification (RFID) tag reader, a Rubee™ device that complies with IEEE standard 1902.1, a bar code reader, or other device capable of reading corresponding identifiers on the goods or the pallet that holds the goods

[0041] In addition to providing control signals to the drive and lift control systems, the vehicle controller **12** furnishes data to a display **55** that presents information to the vehicle operator. That information can include, for example, a number of pallets moved, a number of pallets moved during a period of time (e.g. per hour or per work shift), an average number of pallets moved by the vehicle per day, the weight of each pallet or load, and identification of the goods being transported. In addition, the display indicates vehicle operating parameters, such as for example, the speed of travel, battery charge level, hours of operation, time of day, and maintenance needed to be performed. Although not shown here, temperature sensors can also be included to monitor the temperature of the motors and other components. As used herein the terms "speed of travel" and "travel speed" refer to the rate at which the industrial vehicle **10** moves across the floor of the warehouse. Furthermore, the functions stated hereinafter of restricting or limiting the speed of travel refers to reducing that speed from the level that otherwise could be attained by the industrial vehicle. In other words, the operator would be able to drive the industrial vehicle at a greater speed, if such restricting or limiting did not occur and is not warranted.

[0042] Referring still to FIG. **2**, a number of data input and output devices can also be connected to the vehicle controller **12**, including, for example, vehicle sensors **66** for parameters such as temperature and battery charge level, a user input device **67**, a GPS receiver **68**, a communication port **69**, and a maintenance service port **72**. The user input device **67**

allows the operator, a supervisor, or other personnel to enter data into the vehicle controller **12**, and can be implemented as a touch screen in display **55**, a keyboard, a series of discrete pushbuttons, a mouse, joystick or other input device as will be apparent to those of ordinary skill in the art.

[0043] The communication port **69** is connected to a wireless communication device **71** that has an antenna **75** for exchanging data with a communication system in the warehouse or factory in which the industrial vehicle **10** operates. The wireless communication device **71** includes a transceiver **73** for transmitting messages to and receiving messages from the warehouse communication system. Preferably the transceiver employs radio frequencies, although other optical, ultrasonic and other forms of wireless communication can be used. Any one of several communication protocols such as Wi-Fi can be used to exchange messages and data via that communication link. Each industrial vehicle **10** has a unique identifier that enables messages to be specifically communicated to that vehicle. The unique identifier may be the serial number of the industrial vehicle or a unique address on the warehouse communication system. The unique identifier usually is included in every message sent to and from the industrial vehicle **10**, however some messages are broadcast to all the industrial vehicles in the warehouse by using a broadcast identifier to which all vehicles respond.

[0044] Referring now to FIGS. **3-5**, the communication port **69** is provided in the wiring harness of the industrial vehicle **10** adjacent a housing for the vehicle controller **12**. The wireless communication device **71** includes a mating connector that can be connected directly to the communication port **69**. As shown here, additional connections are made to a terminal strip to provide power connections to the battery **37**. However, it will be apparent that battery power could also be routed directly through additional terminals of the communication port **69**. This connection allows the transmission of sensor data, operational state data, and switch and control state data from the vehicle controller **12** to external equipment. Additionally, because of the direct connection to the vehicle controller **12**, the wireless communication device **71** can receive commands from external equipment and to provide those commands to the vehicle controller. Such commands may limit the speed or acceleration of the vehicle, provide data on a display, and disable vehicle operation, as well as control other functions of the vehicle, as described more fully below.

[0045] Referring again to FIG. **2**, the vehicle controller **12** stores data regarding the operation of the industrial vehicle **10**. That data can include number of hours in operation, battery state of charge, and fault codes encountered. The hours of operation is calculated as a function of the time that the key switch **18** is closed, that the vehicle controller **12** floor switch **13** is depressed, that the lift motor **51** is active, or that the industrial vehicle **10** is traveling based on feedback from rotation sensor **44** connected to the traction motor **43**. In addition, operation of the lift can be monitored using the time that the lift motor **51** is active. Various speed parameters such as speed and acceleration of the vehicle and of the mast **33** can also be monitored. The vehicle operational data is collected and stored in a memory or other storage device within the vehicle controller **12**.

[0046] The vehicle operational data also can include an operator identifier, such as a name or employee number, which is entered through a user input device **67** into to the vehicle controller **12**. Additionally, operator checklists, including those mandated by the U.S. Occupational Safety and Health Administration (OSHA), can be presented to the operator via the display **55**. Data acquired from these checklists can be associated with the operator along with data related to that person's driving parameters. For example, average vehicle acceleration rates and speeds may be monitored, as well as collision data, number of pallets moved, or other data useful in monitoring operator performance and efficiency. The operator employs the user input device **67** to enter responses to the checklist items.

[0047] Referring now to FIG. **6**, a warehouse **100**, in which one or more industrial vehicles **10** operates, includes a communication system **102** that links the vehicles to a centralized warehouse computer system **104**. The communication system **102** includes a plurality of wireless access points **106** distributed through a warehouse **100**, such as in a shipping dock and goods storage areas. The wireless access points **106** are wireless transceivers that are connection via a conventional local area network **105** or a TCP/IP communications link to the centralized warehouse computer system **104**. Alternatively the wireless access points **106** can be wirelessly coupled, such as through a Wi-Fi link, to the warehouse computer system **104**.

[0048] With reference to FIG. **7**, the warehouse computer system **104** includes a processor **80** which executes program instructions stored in a memory **82** that forms part of a storage system **83**. The processor **80** is a commercially available device designed to operate with a Microsoft Windows® operating system, for example. It includes internal memory and I/O control to facilitate system integration and integral memory management circuitry for handling all external memory **82**. The processor **80** also includes a bus driver which provides a direct interface with a multi-bit bus **84**.

[0049] The bus **84** is an industry standard bus that transfers data between the processor **80** and a number of peripheral devices. Those devices include a disc controller **86** which provides a high-speed transfer of data to and from a CD ROM drive **88** and a hard disk drive **90**. A graphics controller **91** couples the bus **84** to a standard monitor **92** through a standard VGA connection **94**, and a keyboard and mouse controller **95** receives data that is manually input through a keyboard **93** and mouse **97**. The bus **84** also connects to a vehicle communication interface **96** that connects to the wireless access points **106**, and an internet interface **98** is provided to link the warehouse computer system **104** to the Internet.

[0050] Returning to FIG. **6**, the management computer system **114** at the headquarters of the warehouse company is similar to that described for the warehouse computer system **104** in so far as the present invention is concerned, except that it is not connected via the local area network **105** to the wireless access points **106**. Thus both warehouse computer system **104** and the warehouse management computer system **114** execute the same software for storing, analyzing and reporting the operating information for the industrial vehicles.

[0051] The connection of the warehouse computer system **104** to the Internet **108**, or other external communication network, couples the warehouse computer system to a database **110** that stores vehicle specific data provided by the manufacturer from a manufacturer computer **112**. Selected data can also be accessed by, for example, warehouse management personnel or vehicle dealers, who can connect to the database **110** through the Internet **108** by way of an extranet or similar system.

[0052] Data stored in the database **110** can be accessed with reference to the serial number of a specific vehicle or a model number and includes, for example, the following:

[0053] Vehicle documentation and parts & service manuals,

[0054] Field service bulletins and other information,

[0055] Options added (vehicle modification history),

[0056] As built Bill of Materials,

[0057] As built vehicle performance information,

[0058] Service and replacement parts history,

[0059] Operating history (impacts, hour meters, fault codes, age),

[0060] Use history (hour meters, fault codes, battery state-of-charge),

[0061] Sale/resale history, and

[0062] Projected end of service date.

Data in the database **110** can be associated with the serial number of a specific vehicle. This serial number can be used to access detailed information about a particular vehicle. Additionally, based on the serial number, the appropriate vehicle documentation, parts and service manuals, and field service bulletins or other information can be accessed.

[0063] Referring still to FIG. **6**, during typical operation, each industrial vehicle **10** in a warehouse transmits messages containing operational data and its serial number through antenna **75** and communication system **102** to the warehouse computer system **104**, which stores the information. The data can be transmitted continuously while the vehicle is operating, at defined time periods, or at the end of a shift. Information gathered from each vehicle **10**, then is relayed occasionally through the Internet **108** to the database **110** and also may be sent to the warehouse management computer system **114** at the headquarters of the warehouse company.

[0064] Because of the bidirectional communications between the vehicle controller **12** and the warehouse communication system **102**, the warehouse computer system **104** can also control vehicle operational parameters. In particular, the system can control the maximum travel speed and acceleration of the industrial vehicle in both the forward and reverse travel directions. Additionally, the mast velocity and acceleration can also be controlled, in both up and down directions. Other vehicle functions, such as the horn, can also be activated by the warehouse computer system **104**, as an alarm when certain operating conditions are detected.

[0065] Thus, for example, the warehouse control system can correlate the work intensity of a vehicle to the level of wear experienced by key components. For example, if a temperature sensor indicates that the component temperatures are rising at a higher than expected rate, but the overall level of productivity is not excessive, it could be concluded that an operator is using the industrial vehicle very hard for a period and then sitting idle. To prevent overheating of the vehicle, the warehouse communication system can limit both the acceleration and maximum speed of the industrial vehicle. The vehicle operation parameters, such as speed and acceleration, can also be limited to control energy consumption of the vehicle, and to promote "green" vehicle usage.

[0066] The data accumulated by the vehicle controller **12** and stored within its memory **24** can be used for a variety of purposes in controlling the operation of the industrial vehicle **10**. One function is to limit the speed and acceleration of the vehicle when a fragile load is being transported. This is accomplished by detecting the characteristics of the load each time that the forks **31** are raised or lowered along the mast **33** as depicted in FIG. **2**. When the vehicle controller **12** sends a motion command to the lift motor control **23**, the controller also commences executing a software load control routine **120** represented by the flowchart in FIG. **8**. That routine commences at step **122** where the vehicle controller inspects the signal from the weight sensor **57** on the fork lift system. If that signal indicates that the forks **31** are not transporting a load, the routine immediately branches to step **132** at which normal operation of the vehicle is restored before the routine ends. Such restoration of normal operation occurs when a previously carried load is removed from the forks and the weight sensor **57** indicates no load.

[0067] Alternatively, when the weight sensor **57** indicates that the forks are now carrying a load at step **122**, the routine advances to step **124** where the vehicle controller **12** reads the signal from the load sensor **58** that is mounted on the mast **33** or the forks **31** so as to read an indicator that is either on the load **35** or the pallet **56** on which the load is held. As noted previously, the load sensor **58** may be any one of a number conventionally known devices for obtaining information from an object. Examples of such sensors include a radio frequency identification tag reader, a Rubee™ device that complies with IEEE standard 1902.1, or a barcode reader. These devices read indicator from the load or pallet which identifies the load being carried. For example, each pallet **56** may have a unique identifier thus distinguishing that pallet from the other pallets in the warehouse. Regardless of whether the indicator is on the load **35** or the pallet **56** the signal from the load sensor **58** is referred to as "the load identifier".

[0068] Then at step **126**, the vehicle controller sends an inquiry message via the communication port **69** and the wireless communication device **71** in FIG. **2** to the warehouse communication system **102** in FIG. **6**. That inquiry message contains the unique identification number assigned to that industrial vehicle **10**, which is used as the vehicle's address in the warehouse communication system **102**. The inquiry message also contains the load identifier which has just been read and a notation that the message is requesting information about that load. The inquiry message is transmitted from the industrial vehicle **10** to the warehouse communication system access point **106** which is nearest to the industrial vehicle. Upon receipt, the access point **106** forwards that message via the local area network **105** to the centralized warehouse computer system **104**. When forwarding the inquiry message, the particular access point **106** includes its local area network address.

[0069] The warehouse computer system **104** recognizes that incoming message as a load query from an industrial vehicle and responds by extracting the load identifier from that message. The load identifier is then utilized to access a database which contains characteristics of the materials that are on each pallet within the warehouse **100**. Specifically, that database information is indexed by the load identifier enabling the warehouse computer system **104** to obtain information about the characteristics of a particular load. Among those characteristics is an indication of whether the load is fragile and thus requires delicate handling. That fragility indication is conveyed by the warehouse computer system **104** in a reply message that is addressed to the industrial vehicle **10** that sent the query. In particular, the industrial vehicle identification number that was carried by the inquiry message is copied into the reply message as the address of the intended vehicle recipient. The local area network address of the par-

ticular access point **106** that processed the inquiry message also is included. The formulated reply message is then transmitted by the warehouse computer system **104** via the local area network **105** to the designated access point **106**, which then transmits the reply message wirelessly to the specified industrial vehicle. Alternatively, the reply message can be sent to all the access points **106**, so that the reply is broadcast throughout the entire warehouse **100** in case the industrial vehicle **10** has moved out of range of the original access point **106**.

[0070] Referring again to FIG. **8** along with FIG. **2**, upon receiving the reply message from the warehouse computer system **104**, the load control routine **120** executed by the vehicle controller **12** advances to step **128**, where the message contents are read to determine whether a fragile load is indicated. If so, the program execution advances to step **130** where the vehicle is set to restricted operation to provide delicate handling of the load. That type of handling can be indicated by setting a fragility flag in the memory of **24** of the vehicle controller **12**, which is read every time the operator desires to operate the traction motor **43** or the lift motor **51**. A set fragility flag causes the vehicle controller **12** to limit the commands sent to the traction motor control **27** and the lift motor control **23**. Thus regardless of the desired motion indicated by the operator's manipulation of the control actuators **41**, the vehicle controller **12** limits the travel speed and rate of acceleration of the traction motor **43** and thus those parameters of the industrial vehicle **10**. The speed at which the load is raised and lowered also is limited by restricting operation of the lift motor **51**. As a consequence, when a fragile or delicate load is being carried, the industrial vehicle is operated in a manner that is less likely to disturb or damage the load.

[0071] If, however, the reply message indicates that the load is not fragile, the load control routine **120** branches from step **128** to step **132** at which the fragility flag within the vehicle controller memory **24** is reset to enable full, normal vehicle operation. This removes any restrictions on the speed or acceleration and thus the vehicle can operate at the maximum levels of those parameters.

[0072] Although it is generally desirable to assign a unique identifier to each pallet of materials within the warehouse so that the particular contents of the load can be identified for other purposes, the indicator on the load **35** or pallet **36** may simply designate whether or not the load is fragile. In other words, the indicator is not unique to a particular load, but one form of the indicator is used on all fragile load and another form is used on all non-fragile loads. In this case, the vehicle controller **12** does not have to interrogate the central warehouse computer system **104** for the fragility information, but can determine onboard whether the load is fragile and thus operate the traction motor accordingly. In this latter case, each industrial vehicle is controlled autonomously.

[0073] In either situation, when the industrial vehicle **10** deposits the load at the end of its transportation and the forks **31** are empty, that condition is detected at step **122** as there being no load on the forks. As noted previously in this condition, a branch occurs to step **132** where the vehicle is reset to normal operation until another fragile load is detected.

[0074] Referring to FIGS. **2** and **9**, the load weight sensor **57** can also be utilized to implement another function that tracks the performance and efficiency of the industrial vehicle **10**. This function is performed by a load performance routine **170** executed by the vehicle controller **12** each time that the lift motor **51** is operated at which time the signal from weight sensor **57** is examined at step **172** to determine whether a new load has just been picked up. Alternatively the load sensor **58** may be used to determine the presence of a load **35** on the forks **31**, however, unless a weight sensor **57** also is included on the vehicle, this technique does not permit monitoring the weight of each load. With either approach, a load flag in the memory **24** denotes whether a load is present on the forks **31**. Therefore, if the weight sensor signal indicates a load on the forks, the routine advances to step **174** at which the load flag is examined. If the load flag already has been set, as occurs when a load was picked up previously, the routine ends until the lift motor **51** is operated again.

[0075] Alternatively, finding the load flag not set at step **174** denotes that a new load was just picked up. Now the routine branches to step **176** at which the load flag is set. Then at step **178**, a count of the loads stored in memory **24** is incremented. Next the weight of the new load is determined at step **180** using the signal from the weight sensor **57** and the resultant value is stored in a load data table maintained in the memory **24**. The length that each load is transported by the industrial vehicle **10** also is measured by starting a load timer at step **182**, and a measurement of the travel distance commences by storing the present odometer value at step **183**. Thereafter the load performance routine **170** terminates until the lift motor **51** is operated again.

[0076] If upon commencing execution of the load performance routine at step **172**, a load is not found on the forks **31**, a branch occurs to step **184** where the load flag is examined. If the load flag is set, then a load was just removed from the forks. This determination causes step **186** to be executed which resets the load flag to denote empty forks. Then at step **188**, the load timer is stopped and at step **190** the load transport time is stored in the memory **24** with the other data for that load. Next at step **191**, the odometer is read and the travel distance and average speed for that distance are computed and stored as part of the load data, before advancing to **192**. Otherwise if at step **184** the load flag was found to denote empty forks, the load performance routine jumps directly to step **192** without storing any load data. The load data thus includes a load count, load weights, transport time, travel distance and average speed and may include other types of data, such as power consumption and idle time, pertaining to operation of the industrial vehicle.

[0077] The load data accumulated in this manner are tabulated during a predefined period, such as an hour, a work shift, or a day. The end of that predefined period can be determined at step **192** by the vehicle controller **12** reading a real time clock, which event causes the control system **20** to wirelessly transmit the load data via the warehouse communication system **102** to the warehouse computer system **104** at step **194**. Instead of using a real time clock, the transmission of the load data may occur in response to a command received from the warehouse computer system **104**, which sequentially sends such commands to all the industrial vehicles in the warehouse. After the transmission of the load data, the controller's memory **24** is cleared at step **196** for another data acquisition period.

[0078] The central warehouse computer system **104** receives similar load data from all the other industrial vehicles **10** within the warehouse **100**. In the present example, the central warehouse computer system **104** in FIG. **6** analyzes load data to determine the performance and efficiency of each vehicle. The analysis of the performance and effi-

ciency of a vehicle may employ benchmark data from the manufacturer and data gathered from vehicle operation at the warehouse.

[0079] Manufacturers of industrial vehicles typically conduct productivity tests that characterize the performance of a particular vehicle model. For example, a standardized test may be defined as a picking up a standard weight load at a specified height, transporting the load over a predefined path of a known distance, depositing the load at a given height, and traveling back to the starting point. During this action sequence, the vehicle operating parameters are sensed and stored. The action sequence is repeated several times to measure the number of such cycles that the vehicle is capable of performing per hour and produce average values for the vehicle operating parameters. This provides productivity benchmark data for that vehicle model.

[0080] The operational data from each industrial vehicle in the warehouse is compared to the productivity benchmark data to determine whether every vehicle is operating according to the manufacturer's specifications. Each vehicle's operational data also is compared to similar data produced by the other warehouse vehicles during the same time period to detect if one or more of them is operating significantly less efficiently than the others. Significant deviation from the benchmark data or the performance of the other vehicles of the same type at the warehouse indicates either a mechanical problem or an inefficient operator. Such deviations are reported to supervisory personnel at the warehouse to assist them in executing their duty to supervise operators and otherwise manage warehouse operations.

[0081] Recently gathered operational data also is compared to similar data gathered over past work periods at the warehouse from the same industrial vehicle and other vehicles of the same type or model. Significant changes in the current data from that gathered in the past also are reported to warehouse supervisory personnel.

[0082] The data can also be utilized to determine the amount of time between loads for each industrial vehicle and thus how much the entire fleet of industrial vehicles is being utilized. The total utilization of the fleet of industrial vehicles can be reviewed to determine whether additional vehicles should be obtained for use in the warehouse or on the other hand whether there are too many vehicles and thus the fleet can be reduced and still provide efficient warehouse operation.

[0083] The vehicle data comparison and analysis can occur at the warehouse computer system **104** in FIG. **6** and be limited to data from the vehicle fleet at that one facility, can occur at the warehouse management computer system **114** and use data from vehicles at a plurality of facilities in the business enterprise, or can occur at the manufacturer computer **112** utilizing data from many companies that use that brand of vehicles. For the latter two processes, the data from several facilities are sent to the warehouse management computer system **114** or the manufacturer computer **112** via the Internet **108** or another communication link. Thus the operating data from one vehicle can be compared to locally or globally gathered data.

[0084] Another function performed using data that is gathered by the control system **20** prevents use of an unauthorized vehicle in a restricted area. As noted above, certain warehouse environments, such as cold storage areas and areas with potentially explosive atmospheres, require special industrial vehicles that are designed to operate in those environments. For example, Type EE industrial vehicles are designed for use in areas where flammable materials are stored and a potential explosion or fire hazard exists if those materials should leak. Type EE vehicles conform to the spark proof characteristics defined in Underwriters Laboratories Standard UL 583. Further, many models of industrial vehicles cannot work satisfactorily in cold environments which adversely affect the battery power and hydraulic systems. As a consequence, special models of industrial vehicles are designed for use in cold storage areas. Many warehouses may have both special areas, such as for cold storage or for flammable material storage, as well as other areas for general purpose storage. Operators are trained that only the specially designed vehicles should be operated within such special areas.

[0085] To reinforce this training, one of the functions that can be implemented by the present industrial vehicle control system **20** is to automatically detect when an unauthorized vehicle is approaching a restricted area and provide a notification to the operator. Thereafter, if the notification is not heeded and the vehicle enters the restricted area, its operation is disabled. With reference to FIG. **2**, this is accomplished by the vehicle controller **12** periodically monitoring its location as indicated by the GPS receiver **68**. That GPS receiver **68** is a conventional device which utilizes the global positioning system comprising a constellation of earth orbiting satellites that continuously transmit signals containing the time in which the message was sent and ephemeris data regarding the precise orbit of the satellite. The GPS receiver **68** onboard the industrial vehicle **10** uses the signals from three or more of those satellites to determine the precise location of the vehicle. Typically, the GPS receiver determines the longitude and latitude of the industrial vehicle.

[0086] Alternatively, the location of the industrial vehicle **10** can be determined from communication with three separate wireless access points **106**. Each wireless access point **106** is assigned a unique address that is included, along with the time of day, in every wireless message sent to an industrial vehicle **10**. Each industrial vehicle **10** has an internal clock and is able to tell the time of day that each message in received. From the transmitted time and the received time, the propagation time of the message from the wireless access point **106** to the vehicle can be calculated. By receiving messages from at least three wireless access points **106**, and by knowing the fixed location in the warehouse of each of those access points and the respective message propagation times, the vehicle location can be determined using triangulation.

[0087] Periodically, such as every few seconds in response to a timed interrupt, the vehicle controller **12** commences executing a location control routine **140** depicted by the flowchart in FIG. **10**. That routine commences at step **142** at which the vehicle controller reads the vehicle location from the GPS receiver **68**. Then at step **144**, the vehicle's location is compared to a database of alert zones, or areas, defined within the warehouse for the associated class of industrial vehicles.

[0088] With additional reference to FIG. **11**, the exemplary warehouse **100** has a room **160** in which flammable materials **162** are stored and which room may have an explosive environment if those materials should spill or leak from their containers. As a consequence, only industrial vehicles **10** that are rated for use in such explosive environments are permitted within room **160**, which is considered to be a restricted area within the warehouse. In addition, an alert zone **165**, having a boundary **166** denoted by a dashed line, is defined within the unrestricted area of the warehouse **100** in front of the door **164**

into the restricted area of room **160**. For example, this alert zone **165** is defined by an alert location **163** in the doorway into the restricted area of room **160**, and by a distance D extending around that alert location, thereby specifying a semicircular boundary **166** of the alert zone. Although the definition of a semicircular or circular alert zone is relatively easy to implement as only two data items are required (the alert location and the distance therefrom), other boundary shapes for the alert zone can be implemented. The specification of the alert zone **165** for a particular industrial vehicle **10** is contained in a database of all such areas of the warehouse, which database is stored in the memory **24** onboard that vehicle. A similar database defining the restricted areas, such as room **160**, for the particular vehicle also is provided within it onboard memory **24**.

[0089] Thus at step **144**, the vehicle controller **12** compares the location information from the GPS receiver **68** to the alert zones specified in its database. When the location of the industrial vehicle **10** is less than distance D from the location of the alert location **163**, a determination is made at step **146** that the vehicle is within the alert zone. If so, the program execution branches to step **148** at which a notification is issued to the vehicle operator. For example, the notification is produced by an annunciator, such as the vehicle's display **55** or the audible alarm **70** (see FIG. **2**). If at step **146**, however, a determination is made that the industrial vehicle **10** is not within one of the defined alert zones, the process branches to step **150** at which any previous alert is deactivated.

[0090] Regardless of whether step **148** or **150** is executed, thereafter the program advances to step **152** where the present vehicle location is compared to the database within the vehicle controller memory **24** indicating the restricted areas. Then at step **154**, a determination is made whether the industrial vehicle **10** has entered a restricted area. Presumably, the operator will have heeded the alert and not entered the restricted area, in which case, the program execution ends. If contrary to his or her training, the operator failed to heed the alert and continued to drive the industrial vehicle **10** into the restricted area, room **160**, that event causes the location control routine **140** to branch to step **156**. At this time, the vehicle controller **12** disables further operation of industrial vehicle **10**. In other words, the vehicle controller deactivates the lift motor **51**, the traction motor **43**, and the steer motor **47**. Other functions of the vehicle also are disabled. Instead of entirely disabling operation, the vehicle controller **12** could severely limit the operation, such as by limiting the speed of travel to an extremely slow maximum level or disabling only some functions. Then at step **158**, the vehicle controller **12** transmits a message through the communication port **69** and the wireless communication device **71** to the warehouse communication system **102** to notify the warehouse computer system **104** that the industrial vehicle has been disabled. In this disabled condition, the vehicle cannot be operated until an authorized person enters a password into the user input device **67** and re-enables vehicle operation. Therefore, the message sent to the warehouse computer system **104** informs supervisory personnel that the industrial vehicle **10** has been disabled and gives the location of that vehicle.

[0091] In the above implementation, the databases of the alert zones and restricted areas are stored in the memory **24** onboard each industrial vehicle **10** which enables the location control routine **140** to be executed on each vehicle's controller **12**. Alternatively, the databases and location control routine **140** can be stored in the warehouse computer system **104**. For each alert zone or a restricted area the database indicate the particular vehicles that are allowed to operate therein. Now, each time a vehicle controller **12** reads a location from the associated GPS receiver **68**, that location along with the vehicle's unique identifier are transmitted wirelessly via the communication system **102** to the warehouse computer system **104**. That computer system **104** then determines, in a manner similar to that described above, whether the vehicle is within either an alert zone or a restricted area in which that vehicle should not operate. If that is true, a message is sent back to the particular industrial vehicle **10** commanding either issuance of an operator alert or disabling the vehicle operation, as is appropriate.

[0092] The vehicle control system **20** also enables the vehicle to be used in an energy conserving or "green" manner. Electrical utility companies have rate programs in which the monetary amount charged for electrical consumption varies at different times of the day. Use of electricity during peak hours, often the daylight hours, under these rate programs typically costs more than use at off-peak hours, which typically occur during the night. When the charge of the vehicle's battery **37** diminishes and needs to be recharged, the battery is removed from the vehicle and placed into a charging station. A battery, that was charged previously, is then inserted into the vehicle for continuing use, while the depleted battery is being recharged. Therefore, it is desirable to perform battery charging at off peak periods when the electrical utility rates are the lowest available. Thus it is desirable to operate the industrial vehicle in a manner which will conserve the electrical power during times at which battery replacement requires use of another battery that was charged during peak rate periods of the day. In other words, it is desirable to operate the industrial vehicle in a manner so that the battery life is prolonged until a time period when a replacement battery that has been charged during lower electrical rate periods is available.

[0093] To accomplish this, the vehicle controller **12** controls operation of the traction motor **43** so as to limit the maximum speed at which the vehicle can travel and its rate of acceleration, thereby using battery power most efficiently. In addition, the lift motor **51** that drives the pump can be operated in a similar energy conserving manner. As a consequence, even though the vehicle operator may manipulate the control actuators **41** in a manner that normally would produce rapid acceleration or a high vehicle travel speed, the vehicle controller **12** restricts that acceleration rate and the speed during periods in which the battery **37**, if depleted, would have to be replaced by a battery that was charged during peak electrical rate periods. On the other hand, during off peak electrical use periods, such as at night, the limits on the vehicle's speed and acceleration are removed so that the vehicle is able to operate at the maximum speed and rate of acceleration possible.

[0094] To implement this energy conservation, the vehicle controller **12** has either a time of day clock or receives the time of day from the warehouse computer system **104** via the communication system **102**. When it is desired to activate the traction motor **43**, the vehicle controller queries a table of time periods of limited use that is stored in memory **24**. If the current time of day is within one of those periods, the vehicle controller **12** limits the commands sent to the traction motor control **27** to regulate the vehicle acceleration and speed for energy conservation.

[0095] Another function of the onboard vehicle control system **20** facilitates the maintenance, repair and servicing of the industrial vehicle **10**. As noted previously, a particular industrial vehicle may have any of numerous optional features incorporated by the manufacturer based on the order from a purchaser. When a service technician goes to the warehouse to perform maintenance or repairs on a particular industrial vehicle, that technician needs to know the "as built" configuration of that vehicle in order to know the proper maintenance procedures to perform and how to diagnose the source of a particular problem. Heretofore the "as built" information was not readily available to the service technician on the job site, unless that information was obtained from the manufacturer before being the technician was dispatched to the warehouse. In addition, the technician's service van previously had to carry an extensive library of manuals for all the different models of industrial vehicles that could possibly be serviced by the technician, as well as manuals for all the available optional features.

[0096] To facilitate such maintenance and repair work, service information regarding each specific industrial vehicle **10** is stored within the memory **24** of its vehicle controller **12** in FIG. **2**. Service information includes trouble shooting manuals, repair manuals, parts manuals, operating manuals, service bulletins, bills of materials, "as built" information related to the particular vehicle, and other information related to maintaining, repairing and servicing the vehicle. This information can be initially stored by the manufacturer as part of the manufacturing process. Thereafter, as service bulletins are issued, parts numbers change, and other data becomes available, the manufacturer can transfer that data from its computer **112** in FIG. **6** through the Internet **108** to the warehouse **100** where a related vehicle is being used. Upon receipt, the warehouse computer system **104** relays that new information via the local area network **105** and the wireless access points **106** to the specific industrial vehicles **10** to which the information pertains. In addition, each time that a particular industrial vehicle **10** is serviced, a service log within its memory **24** is updated to include references to that servicing so that the log contains an entire service record.

[0097] Upon beginning work on a particular industrial vehicle **10**, a technician plugs a laptop computer into the service port **72** of the control system shown in FIG. **2**. In addition or as an alternative to the service port **72** for a hardwired connection, a wireless interface, such as one using the Bluetooth or WiFi communication protocol, can be provided to communicate between the industrial vehicle and the laptop computer. This enables the technician to read conventional fault codes generated by the vehicle controller **12** which indicate particular problems that the vehicle encountered, as is conventional practice. The technician then can select one of the fault codes which causes the laptop computer to send a query message to the vehicle controller **12** seeking more information related to the fault code. The vehicle controller responds by accessing the library of manuals and service bulletins to obtain information relating to the procedures to diagnose the cause of the fault code. Thus the vehicle controller **12** automatically accesses the proper materials in its library to aid the technician in servicing the industrial vehicle. Furthermore, once the problem has been diagnosed, the vehicle controller **12** also automatically accesses the respective portions of the service manuals describing the procedure for rectifying the problem and how to replace components.

[0098] In addition, the laptop computer connected via the service port **72** can access the "as built" information for the particular vehicle being serviced which greatly aids the technician understanding of the devices on the vehicle and their operation. Once the correct service procedures are identified in the manuals, the vehicle controller **12** also produces an indication of the parts that are required to effect the repair including their part numbers. Alternatively, the user input device **67** of the vehicle can be employed to access this information which then is presented to the technician via the onboard display **55**. By storing such information in the vehicle's memory **24**, the service technician is not required to gather detailed information about the specific vehicle to be serviced nor does the service van have to carry a complete library for servicing all the different vehicle models and configurations that are possible.

[0099] The foregoing description was primarily directed to a certain embodiments of the industrial vehicle. Although some attention was given to various alternatives, it is anticipated that one skilled in the art will likely realize additional alternatives that are now apparent from the disclosure of these embodiments. Accordingly, the scope of the coverage should be determined from the following claims and not limited by the above disclosure.

1. A method for operating an industrial vehicle, said method comprising:

storing repair information in a database contained in a computer system onboard the industrial vehicle, wherein the repair information is customized to the specific optional features incorporated into the industrial vehicle;

upon occurrence of an operating problem, the industrial vehicle generating a fault code designating the operating problem; and

utilizing the fault code to access the database and obtain the repair information associated with the operating problem.

2. The method as recited in claim **1** further comprising displaying, on a display device mounted on the industrial vehicle, the repair information associated with the operating problem.

3. The method as recited in claim **1** wherein the database contains one or more of a repair manual, a parts manual, an operating manual, a service bulletin, and a bill of materials.

4. The method as recited in claim **1** further comprising occasionally adding service bulletins to the database.

5. The method as recited in claim **1** wherein the repair information describes a process for diagnosing a cause of the operating problem.

6. The method as recited in claim **1** wherein the repair information describes a process for identifying a component of the industrial vehicle which caused the operating problem.

7. The method as recited in claim **6** further comprising the computer system placing an order for a replacement component of the industrial vehicle.

8. The method as recited in claim **1** wherein the repair information describes a process for replacing a component of the industrial vehicle which caused the operating problem.

9. The method as recited in claim **1** further comprising storing, in the database, as built information about the specific optional features incorporated into that industrial vehicle.

10. The method as recited in claim **1** further comprising displaying the as built information on a display device attached to the industrial vehicle.

11. A method for operating an industrial vehicle, said method comprising:

storing, in a database contained in a computer system onboard the industrial vehicle, repair information for the industrial vehicle and as built information about specific optional features incorporated into that industrial vehicle;

upon occurrence of an operating problem, the industrial vehicle generating a fault code designating the operating problem; and

the industrial vehicle utilizing the fault code to access the database and obtain the as built information and the repair information associated with the operating problem.

12. The method as recited in claim **11** further comprising displaying, on a display device mounted on the industrial vehicle, the repair information associated with the operating problem.

13. The method as recited in claim **11** further comprising displaying the as built information on a display device mounted on the industrial vehicle.

14. The method as recited in claim **11** wherein the repair information describes a process for diagnosing a cause of the operating problem.

15. The method as recited in claim **11** wherein the repair information describes a process for identifying a component of the industrial vehicle which caused the operating problem.

16. The method as recited in claim **15** further comprising the computer system placing an order for a replacement component of the industrial vehicle.

17. The method as recited in claim **11** wherein the repair information describes a process for replacing a component of the industrial vehicle which caused the operating problem.

18. The method as recited in claim **11** wherein the database contains one or more of a repair manual, a parts manual, an operating manual, a service bulletin, and a bill of materials.

19. The method as recited in claim **11** further comprising occasionally adding service bulletins to the database.

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