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(54) **METHOD AND APPARATUS FOR WIRELESS INFORMATION TRANSFER IN VEHICLE SERVICE SYSTEMS**

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(52) **U.S. Cl.** **700/279**; 356/139.09; 356/155;
280/86.75; 33/288

(58) **Field of Search** 700/279; 356/139.09,
356/155; 280/86.75; 305/116; 33/288

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Primary Examiner—Leo Picard

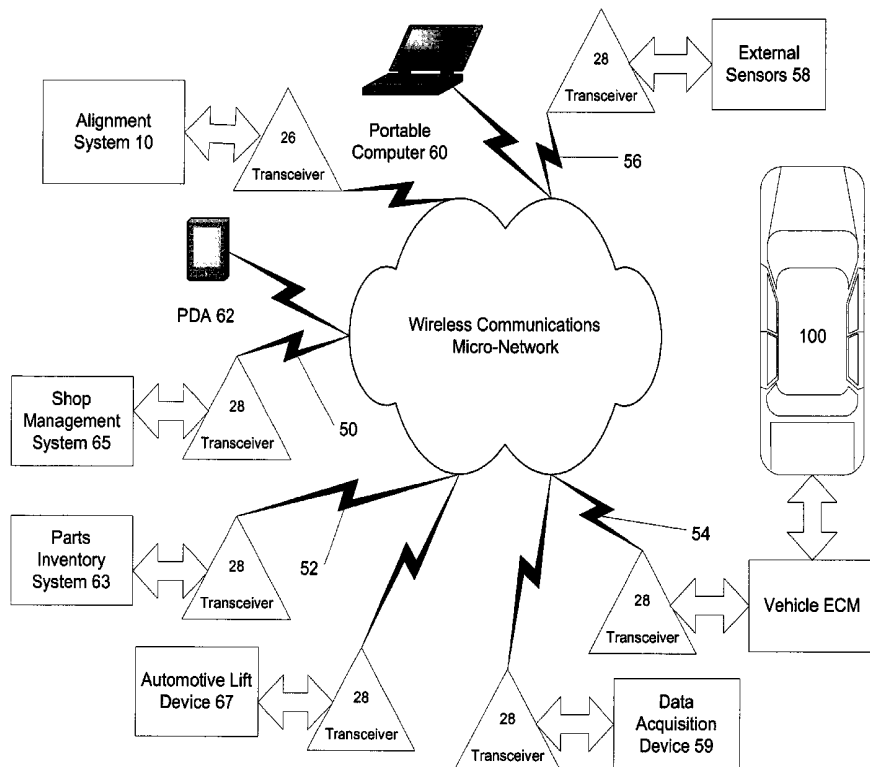
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(57) **ABSTRACT**

A vehicle service system wherein a computer is configured for active wireless communication over a wireless micro-network with any of a variety of similarly configured external components and devices brought into proximity with the computer, including, but not limited to, sensors, input and output devices, mobile computers, onboard vehicle computers, and other vehicle service equipment.

20 Claims, 4 Drawing Sheets



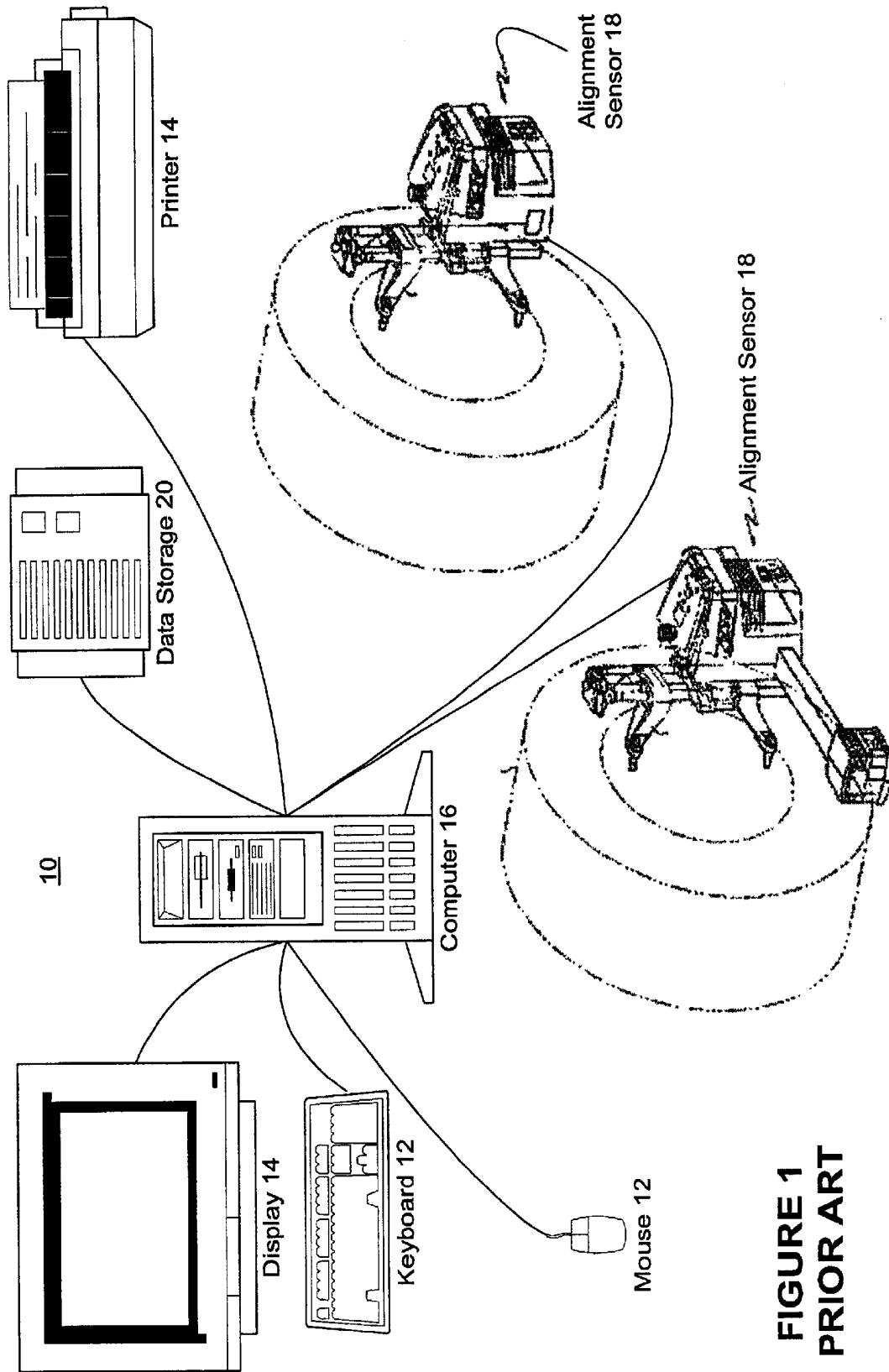


FIGURE 1
PRIOR ART

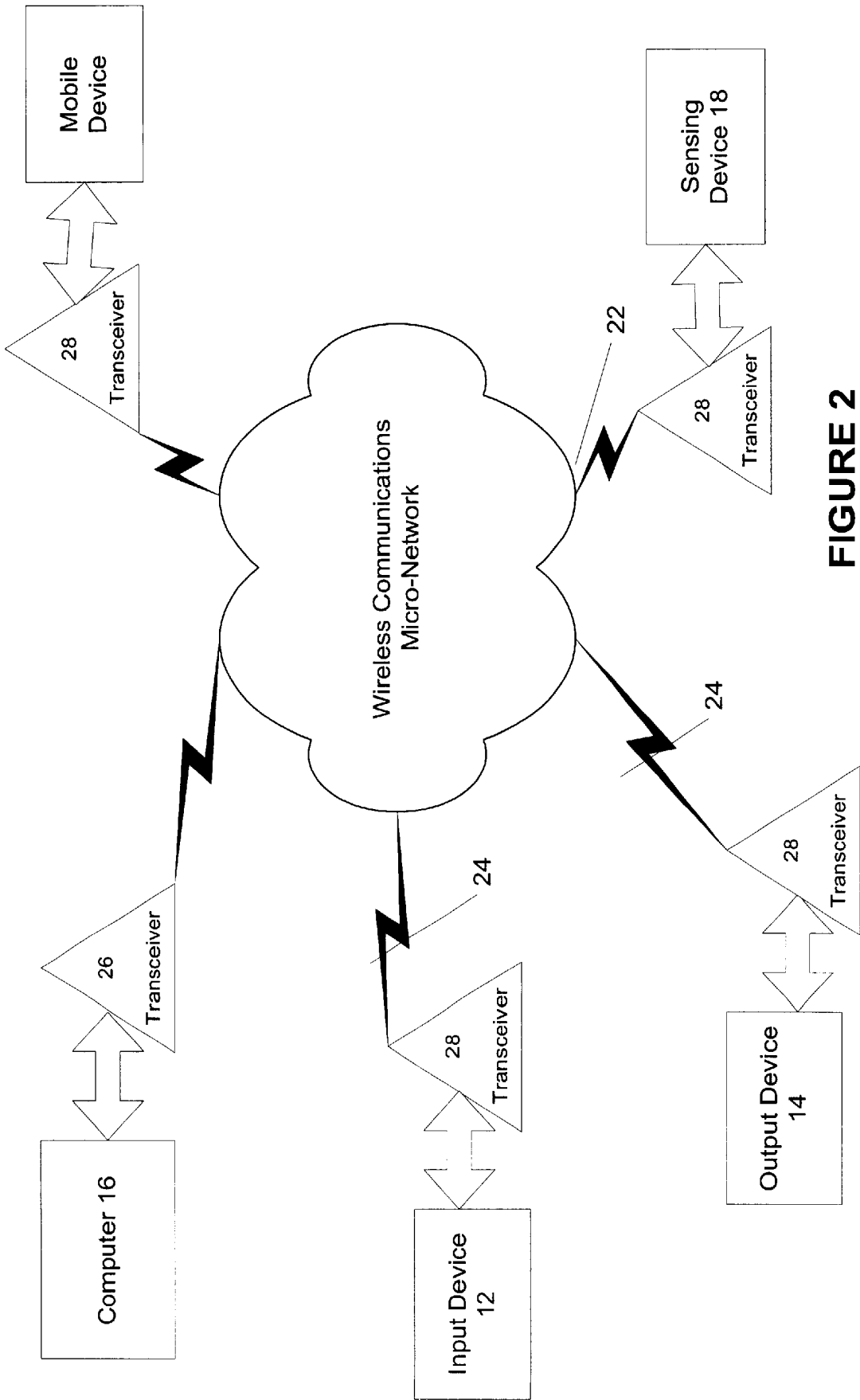


FIGURE 2

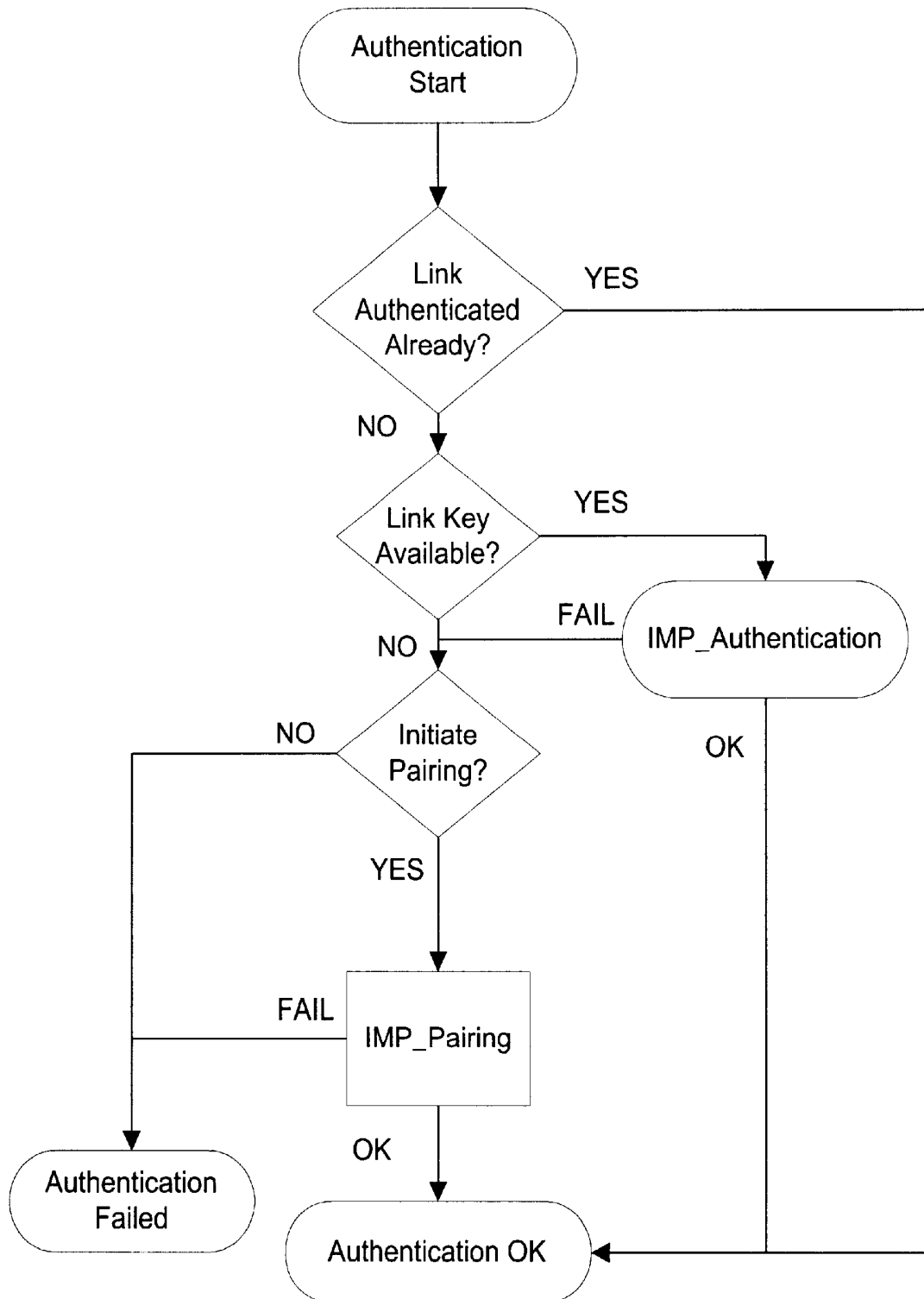


FIGURE 3

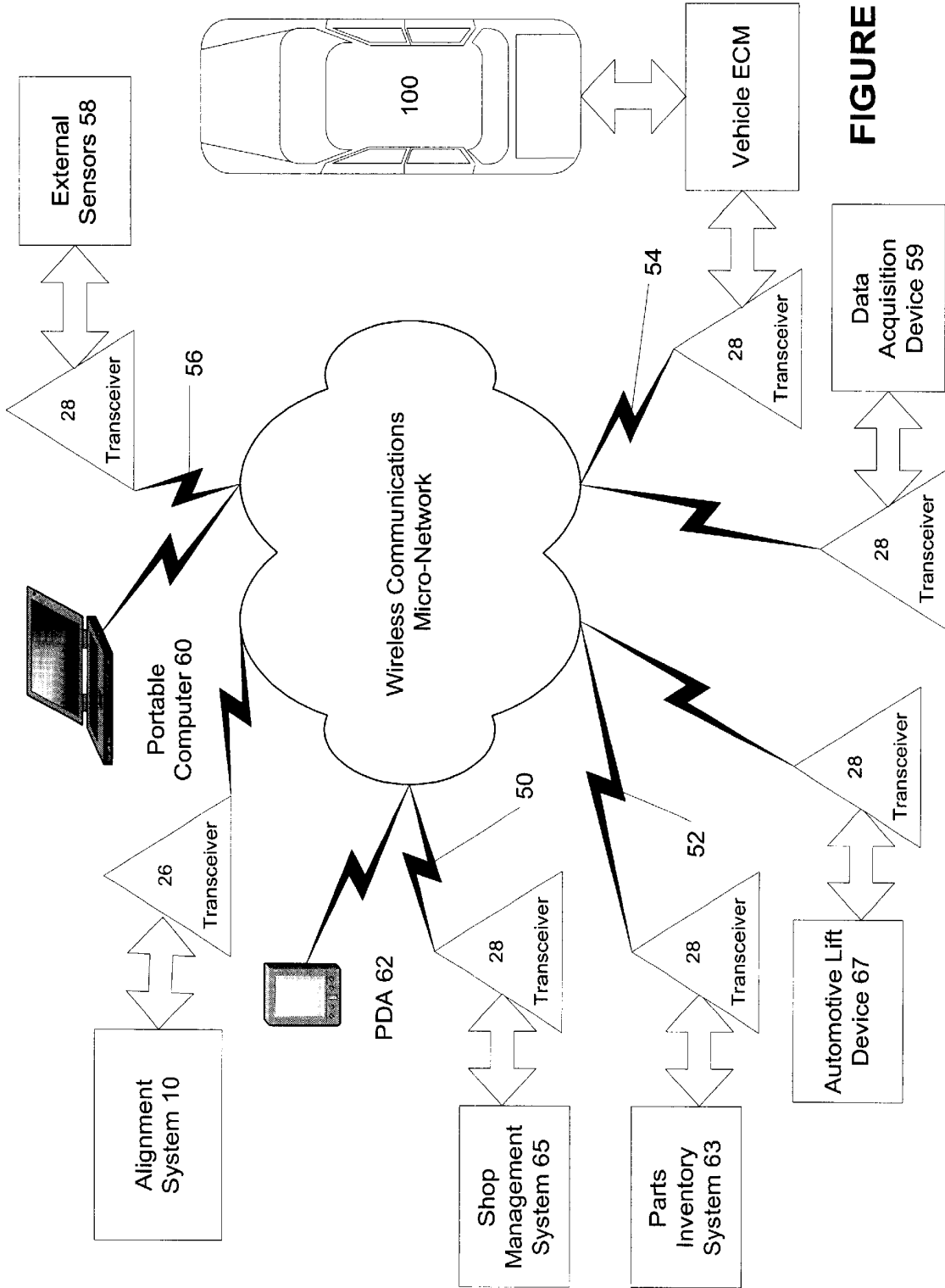


FIGURE 4

METHOD AND APPARATUS FOR WIRELESS INFORMATION TRANSFER IN VEHICLE SERVICE SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

None.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable.

BACKGROUND OF THE INVENTION

The present invention related generally to vehicle service systems having a computer configured to receive information to be utilized in performing a vehicle service, and more particularly, to a vehicle wheel alignment system having computers configured to utilize wireless communications protocols to identify and communicate with a variety of proximally located external devices for the purpose of establishing communication links.

Traditional vehicle wheel alignment systems, such as shown in U.S. Pat. No. 4,381,548 to Grossman et al., herein incorporated by reference, utilize a computing device, typically a general purpose or IBM-PC compatible computer, configured with wheel alignment software, which is connected to one or more vehicle wheel alignment angle sensors. The computing device is configured with software to compute angular relationships of the vehicle wheel, as is described in U.S. Reissue Pat. No. 33,144 to Hunter, et al. herein incorporated by reference, and typically is in communication with a variety of conventional input and output devices, such as keyboards, pointing devices, printers, displays, and audio components. Traditional vehicle wheel alignment sensors comprise angle transducers, such as shown in U.S. Pat. No. 5,489,983 to McClenahan et al., herein incorporated by reference, which are mounted to the wheels of a vehicle undergoing an alignment service, but may comprise camera systems, such as shown in U.S. Pat. No. 5,870,315 to January, herein incorporated by reference, designed to observe either the wheels themselves or targets mounted to the wheels, and to generate images from which alignment angles may be determined by the computing device.

In prior art wheel alignment systems, the individual wheel alignment sensors are connected to the computing device by means of data communication cables. As the wheel alignment systems evolved, the data communication cables have been replaced by wireless communications technologies such as infrared and radio-frequency communication links, wherein the computing device serves as a controller, transmitting instructions to the individual wheel alignment sensors, and receiving wheel alignment information in response. To avoid conflicting communications, individual wireless wheel alignment sensors employ a passive communications system which transmits information to the computing device only in response to specific instructions received therefrom.

In addition to requiring information from individual wheel alignment sensors, a wheel alignment system or other vehicle service system computing device requires information identifying the type of sensors which it is utilizing, information related to the vehicle undergoing service, and information identifying the manner and format of any output

provided to the operator or technician. These various pieces of information are traditionally entered into the computing device manually, via the conventional input devices such as the keyboard or mouse.

Emerging wireless communication technology, such as the Bluetooth wireless communications protocol, enables devices and appliances to interconnect in the form of a mobile and amorphous network capable of continually reconfiguring as elements are added and removed. Bluetooth technology allows easy connection between devices and components, such as smart handheld devices and stand-alone equipment (i.e. general purpose computers to peripherals, etc) without the restrictions of cables or wires. Devices employing the Bluetooth communications protocol can connect with multiple similarly configured devices located within a close proximity, forming a high-speed data network. The Bluetooth communications protocols include user authentication, data encryption and data hopping facilities to protect privacy and to automatically prevent signal interference and loss. These protocols enable automatic synchronization between Bluetooth-enabled devices.

As manual entry of information can be time consuming and repetitive, it would be advantageous to provide a vehicle wheel alignment system wherein individual components were capable of automatically accessing and communicating with a wireless micro-network including a variety of devices located in proximity to the wheel alignment or vehicle service system, and for automatically acquiring from or delivering to, these devices at least a portion of the information required to complete a vehicle wheel alignment or vehicle service procedure.

BRIEF SUMMARY OF THE INVENTION

Briefly stated, in one aspect, the present invention comprises an improved vehicle service system wherein a computing device is configured for active wireless communication with any of a variety of similarly configured external components and devices brought into proximity with the computing device, including, but not limited to, sensors, input and output devices, mobile computers, on-board vehicle computers, and other vehicle service equipment.

In a second aspect, the present invention comprises an improved vehicle wheel alignment system wherein the computing device is configured to utilize a low-power radio-frequency transceiver operating in the 2.4 MHz ISM band, modulated by a gaussian frequency shift keying to communicate with any of a variety of similarly configured external components and devices brought into communications proximity with the computing device. The computing device and the devices with which it is in communication forming a loosely-coupled wireless communications micro-network into which components and devices may be added and removed without disruption.

In a third aspect, the present invention comprises an improved vehicle wheel alignment system wherein the computing device is configured to utilize a wireless Bluetooth communications protocol to communicate with any of a variety of similarly configured external components and devices brought into communications proximity with the computing device, including, but not limited to, alignment sensors, input and output devices, mobile computers, on-board vehicle computers, and other vehicle service equipment.

In a fourth aspect, the present invention comprises an improved vehicle wheel alignment system wherein the computing device is configured to utilize a wireless communi-

cations protocol to communicate with at least one similarly configured processor on-board a vehicle being serviced to retrieve information stored in a memory associated with the vehicle processor, vehicle system data, and/or to store information in the vehicle processor associated memory. Such information may include, but is not limited to, OEM vehicle alignment specifications, vehicle operating parameters, previous vehicle alignment measurements, and current vehicle alignment measurements.

The foregoing and other objects, features, and advantages of the invention as well as presently preferred embodiments thereof will become more apparent from the reading of the following description in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

In the accompanying drawings which form part of the specification:

FIG. 1 is an overview of prior art components in a vehicle wheel alignment system;

FIG. 2 is block diagram illustrating various components of a vehicle wheel alignment system of the present invention linked to a wireless communications micro-network;

FIG. 3 is a flow-chart illustrating a Bluetooth link authentication procedure; and

FIG. 4 is a block diagram illustrating exemplary external systems which may be in wireless communication via the micro-network with the wheel alignment system of the present invention.

Corresponding reference numerals indicate corresponding parts throughout the several figures of the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The following detailed description illustrates the invention by way of example and not by way of limitation. The description clearly enables one skilled in the art to make and use the invention, describes several embodiments, adaptations, variations, alternatives, and uses of the invention, including what is presently believed to be the best mode of carrying out the invention.

Turning to the figures, there is shown the components of a conventional vehicle wheel alignment system generally at **10**. The vehicle alignment system **10** includes at least one input device **12**, such as a keyboard, mouse, microphone, or touch screen, for use by an operator or technician (not shown) to communicate with the vehicle alignment system **10**, and at least one output device **14**, such as a display or audio speaker for the alignment system **10** to convey information to the operator or technician.

Depending upon the needs of the operator or technician, the input and output devices may include, but are not limited to, one or more of the following conventional devices such as a keyboard, a pointing device, a remote control device, a monitor or LCD display, or audio components. The devices can be integrated together in a console, or located separately, again depending upon the needs of the operator and the configuration of the wheel alignment system **10**.

The input devices **12** and output devices **14** are in communication with a computing device **16** such as a wheel alignment computer, operating under control of one or more software programs or components. The computing device **16** can be any computing device used with systems of complexity similar to that of a vehicle wheel alignment system.

For example, a micro-processor, a micro-controller, a digital signal processor having sufficient computing power, or a general purpose computer can be used as the computing device. Of course, any equivalent device, i.e. one capable of executing the requisite software programs or components, can also be used. Communication between the input devices **12**, output devices **14**, and the computing device **16** can be performed electronically or electro-magnetically (including optical communications such as infrared system), or by any combination thereof.

The computing device **16** of the vehicle wheel alignment system **10** is additionally suitably connected to at least one alignment angle sensing device **18** for obtaining measurements of the various alignment angles and/or characteristics of a vehicle under test. The sensing devices **18**, depending upon the application and requirements, can be electronic, electromechanical, or optical. The sensing devices **18** can be hard-wired to the computing device **16** for communication therewith, or can be in communication with the computing device **16** in any other suitable manner, such as through infrared or radio-frequency communication.

In addition to the input devices **12**, output devices **14**, and sensing devices **18**, the computing device **16** of the vehicle wheel alignment system **10** can be configured with access to an internal or external data storage component (collectively identified as **20**), and to various peripheral components, such as printers, CD-ROM drives, DVD-drives, and/or a communications network such as the Internet.

It is preferred that at least one of the communication links between the computing device **16** and either the input devices **12**, output devices **14**, and sensing devices **18** be a wireless communications link. Such communications links are shown in FIG. 2, in which the links between the computing device **16** and at least one sensing device **18** are labeled **22**, and the link between the computing device **16** and an input or output device is labeled **24**.

In the preferred embodiment, a wireless communications system and protocol known as Bluetooth is employed to automatically establish the wireless communications link **22** and/or **24**, forming a wireless micro-network such as a piconet, comprising two to eight communicating devices sharing a communications link, or a scatternet, comprising two or more interconnecting piconets. Alternative wireless communications systems and protocols may be employed for establishing a wireless communication link between devices to form a micro-network. Such systems and protocols, which can be employed with the present invention include HomeRF and Wireless Fidelity, also known as Wi-Fi, or the IEEE 802.11 B standard, although such systems and protocols may not automatically establish communication links, but rather require individual links to be manually initiated.

To establish a Bluetooth wireless communications link, a first radio transceiver **26** is associated with the computing device **16**, and a second radio transceiver **28** is associated with each other device to which a wireless communications link is to be established, such as an input device **12**, output device **16**, or sensing device **18**.

The first and second radio transceivers **26**, **28** are configured to automatically find and contact each other to establish a wireless communications link upon being brought into proximity with each other. Proximity for purposes of establishing a low-power wireless communications link is approximately 10 meters or less with current Bluetooth systems, and for establishing a high-power wireless communications link is 100 meters or less with current Bluetooth

systems. However, those of ordinary skill in the art will recognize that this distance may vary with the communications protocols and technology employed, and as such, may be increased with future versions of Bluetooth. Systems utilizing the Bluetooth communications protocol transmit, using a preferred communications format, a general inquiry (or in some cases, a limited inquiry), which is received and acknowledged by similarly configured devices located within receiving range. Once a second Bluetooth configured device is identified, a link is established and authenticated.

Establishing a Bluetooth link authentication involves a sequence of steps, a portion of which are shown in FIG. 3. First, the initiating Bluetooth system checks to see if a link between the two communicating devices has already been previously established. If a link has been previously established, the authentication is automatically accepted by the initiating Bluetooth device. For the first time only that two devices communicate, an initialization procedure is needed to create a common link key in a safe manner. This procedure is called pairing.

An authentication procedure first checks to see if a link between the two devices has been already authenticated. If so, the authentication is confirmed. If the link between the two devices is not currently authenticated, but a common link key exists between the two devices (from a previous link), the authentication procedure re-authenticates the link. If the re-authentication fails, or if there are no common link keys available between the two devices, the authentication procedure initiates the pairing procedure to generate a new set of link keys between the two devices. Successful completion of the pairing procedure results in the establishment of an authenticated link between the two devices. A complete description of the Bluetooth authentication procedures may be found in the Bluetooth White Paper entitled "Bluetooth Security Architecture", Version 1.0, published Jul. 15, 1999. Those of ordinary skill in the art will further recognize that a variety of authentication procedures may be implemented to compliment different communications protocols.

Turning again to FIG. 2, it can be seen that the vehicle wheel alignment system 10 of the present invention can include wireless communications links with both fixed and mobile devices to establish a micro-network. For example, the transceiver 26 associated with the wheel alignment system 10 is fixed, while a second transceiver 28 associated with a portable display unit is mobile. Devices with which the vehicle wheel alignment system 10 of the present invention can establish a communications link include, but are not limited to computers associated with a vehicle undergoing service, customer computers (laptops and PDAs), input and/or output devices, and other vehicle service equipment.

For example, if a motor vehicle 100 equipped with a suitable transceiver 28 is brought into proximity with a vehicle wheel alignment system 10 of the present invention configured with a transceiver 26 and suitable communications protocols, a communications link will be automatically established between the vehicle 100 and the alignment system 10. In the case of a motor vehicle 100, the suitable transceiver 28 can comprise a self-contained device built in to the vehicle systems, or may comprise a detachable unit designed to plug in to an access point to the vehicle's diagnostic systems, thereby providing wireless access thereto. Utilizing this communications link, the vehicle wheel alignment system 10, or other vehicle service system, can obtain required information directly from the vehicle 100 without the need for the operator or technician to manually enter the data or connect cables from the vehicle's computers to the alignment system.

Such information can include, but is not limited to, diagnostic information stored in the vehicle's electronic control module (ECM), the vehicle identification number (VIN), vehicle tire pressure from associated pressure sensors, stored error codes, steering wheel position encoder signals, electronic ride-height system signals, rear wheel steering information, brake actuation signals, engine status information, power steering status information, and throttle position sensor signals. In the context of a vehicle brake testing system, information which may be communicated from the vehicle to the service system can include, but is not limited to, braking system status, braking hydraulic pressure readings, brake pedal pressure, tire pressure, and vehicle wheel speed.

Additional information which can be stored in a vehicle computer, and communicated to the vehicle wheel alignment system 10 or other vehicle service device over the wireless communications link can include vehicle specifications and previous vehicle service information such as previous alignment measurements, last service date, and the name or location of the service shop performing the last vehicle service.

In addition to receiving information from a vehicle 100, the vehicle wheel alignment system 10, or other vehicle service system, can communicate via the wireless communications micro-network with integrated sensors and components on the vehicle to direct their operation, or to store data in an onboard vehicle storage memory. For example, upon completion of a vehicle wheel alignment procedure, the vehicle wheel alignment system 10 of the present invention can communicate the vehicle's current alignment measurements to the vehicle storage memory via the wireless communications micro-network.

It is preferred that the transceivers of the system operate in the 2.4 GHz Industrial Scientific and Medical (ISM) band to establish the wireless communications micro-network, which is standard for communications devices employing the Bluetooth communications protocols. Those of ordinary skill in the art will readily recognize that the wireless communication between the various devices and the wheel alignment system 10 of the present invention can utilize a wide range of frequency bandwidths, as is appropriate in the environment within which they are intended to operate.

Each of the transceivers 26, 28 is preferably a low-powered device, having a maximum output power of substantially not more than 100 mW in high-power mode, and 10 mW in low-power mode, as is consistent with devices employing the current Bluetooth communications protocols. Such low power transceivers 26, 28 are particularly suited for use with a vehicle wheel alignment system 10 operating in an enclosed vehicle service center, and which are unlikely to require communication with devices other than those located within the proximity of the vehicle service center. However, an output power of greater than 100 mW could be used with different communication protocols or future Bluetooth protocols.

It is anticipated that a vehicle wheel alignment system 10 of the present invention can simultaneously be in wireless communication with more than one similarly configured device, thereby establishing an adaptable wireless communications micro-network wherein data can be exchanged between the devices. As additional devices move, or are brought into, communications proximity to the wireless network, they are automatically or manually added to the network if they are successfully authenticated. Alternatively, as devices move, or are removed, from communications proximity to the wireless network, they are removed from the network.

In contrast with passive network prior art systems wherein a single device functions as a network control device, transmitting instructions to connected devices, and receiving information there from only in response to the transmitted instructions, the wireless micro-network of the present invention permits active bi-directional communication and information exchange between any interconnected devices, with the communication or information exchange being initiated by either of the devices.

Referring to FIG. 4, a vehicle wheel alignment system 10 of the present invention is shown configured with a first wireless communications transceiver 26 and suitable communications protocols as described above. FIG. 4 provides a visual representation of exemplary wireless communications links forming a wireless micro-network which can be established between the vehicle wheel alignment system 10 and an exemplary variety of external devices during a typical vehicle wheel alignment service procedure. In addition to wireless links to standard input and output components 12, 14 such as keyboards, headsets, audio devices, and display units, prior to the arrival of a vehicle 100 at the vehicle wheel alignment system 10, wireless communications links 50 and 52 can be established between the vehicle wheel alignment system 10 and one or more service shop supporting computers, such as a shop management system and a parts inventory system. These links 50, 52 can be maintained throughout an entire vehicle service procedure, so long as the devices remain within the required proximity, and information exchanged over them can include items such as lists of scheduled service appointments, customer information, and parts inventory information. Links to external networks, such as the Internet can also be provided through the wireless links 50, 52 to associated computer systems.

When a vehicle 100 is brought into proximity to the vehicle wheel alignment system 10, additional wireless communication links can be established. For example, a link 54 can be established directly to the vehicle's electronic control module (ECM) and on-board sensors if the vehicle is configured with a suitable transceiver, or can be established indirectly thereto through a plug-in transceiver module connected to the vehicle's ECM system. Information acquired directly from the vehicle through link 54 can include the vehicle VIN, prior service history, current vehicle status, live vehicle sensor readings, and any information stored in on-board vehicle memory storage.

Additional wireless communications links 56 can be established to one or more external sensors 58 or data acquisition devices 59 utilized to acquire data and measurements related to the vehicle 100. For example, individual wheel-mounted alignment angle sensors can be provided with suitable transceivers and communications protocol to establish communication links to the wireless micro-network, rendering sensor data and measurements available to any similarly connected components as well as permitting the vehicle wheel alignment system 10 to control the sensors.

During a wheel alignment procedure or other vehicle service, the vehicle wheel alignment system 10 may communicate via the wireless micro-network with any of a variety of input and output devices configured with suitable transceivers and wireless communications protocols. In addition, wireless communications links may be established to portable computers 60 or PDAs 62 brought into proximity to the vehicle wheel alignment system 10, and information exchanged therewith.

For example, upon completion of a vehicle wheel alignment procedure or other vehicle service, a customer's PDA

62 or laptop computer 60, may receive from the vehicle wheel alignment system 10 an indication that the service has been completed, as well as an update of the results. In response, the PDA 62 or laptop computer 60 may provide payment authorization from the customer to the vehicle wheel alignment system 10. Communication links may further be established to a parts inventory system 63, a shop management system 65, or other vehicle service components, such as an automotive lift rack 67.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results are obtained. As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An improved vehicle wheel alignment system having a computing device, an associated display, and at least one vehicle wheel alignment sensor configured for communication with the computing device for communicating wheel alignment data, said improvement comprising:

a first transceiver unit associated with said computing device;

at least one additional transceiver unit associated with at least one external device located in proximity to said first transceiver unit; and

wherein said first transceiver unit is configured to establish an active bi-directional wireless communications link with said at least one additional transceiver unit, said established wireless communications link comprising at least a portion of an adaptable wireless communications network; and

wherein said computing device and said at least one external device are each configured to initiate communication and information exchange over said established wireless communications link.

2. The improved vehicle wheel alignment system of claim 1 wherein said first transceiver unit is further configured to automatically identify the presence of said additional transceiver unit upon said additional transceiver unit positioned within proximity to said first transceiver unit; and to subsequently establish said active bi-directional communication link.

3. The improved vehicle wheel alignment system of claim 1 wherein said computing device and said first transceiver unit are configured to utilize the Bluetooth wireless communications protocol; and

said adaptable wireless communications network comprises a Bluetooth network.

4. The improved vehicle wheel alignment system of claim 1 wherein said computing device and said first transceiver unit are configured to utilize the Wireless Fidelity wireless communications protocol; and

said adaptable wireless communications network comprises a Wireless Fidelity network.

5. The improved vehicle wheel alignment system of claim 1 wherein said computing device and said first transceiver unit are configured to utilize the HomeRF wireless communications protocol; and

said adaptable wireless communications network comprises a HomeRF network.

6. The improved vehicle wheel alignment system of claim 1 wherein said external device associated with said at least one additional transceiver unit is not a vehicle wheel alignment sensing device.

7. The improved vehicle wheel alignment system of claim 1 wherein said at least one additional transceiver unit is associated with said at least one vehicle wheel alignment sensor; and

wherein said vehicle wheel alignment sensor is configured to communicate with said computing device via said wireless communications network.

8. The improved vehicle service system of claim 1 wherein said computing device is configured to receive information over said wireless communications link associated with at least one vehicle undergoing a vehicle service procedure in proximity to said improved vehicle wheel alignment system.

9. The improved vehicle service system of claim 8 wherein said information is representative of a current measurement of at least one of the following vehicle parameters: braking pressure, wheel turning information, ride-height information, engine status, power steering status, tire pressure, wheel toe angle; wheel camber angle; wheel caster angle; wheel SAI angle; steering wheel position; anti-lock brake information; accelerometer information; wheel braking force; vehicle wheel speed; or vehicle brake pedal pressure.

10. The improved vehicle service system of claim 8 wherein said information includes predetermined vehicle specifications.

11. An improved vehicle service system having a computing device, an associated display, and at least one sensor configured for communication with the computing device for communicating vehicle data, said improvement comprising:

a transceiver unit associated with said computing device, said transceiver configured to establish an active bi-directional wireless communications link between said computing device and a vehicle computer associated with a vehicle in proximity to said improved vehicle service system; and

wherein said computing device is configured to utilize said wireless communications network to receive data from said vehicle computer, and to store updated data in an onboard memory of said vehicle electronic control module computer.

12. The improved vehicle service system of claim 11 wherein said updated data includes one or more current vehicle measurements.

13. A method for transferring information in a vehicle wheel alignment system in communication with a wireless network, comprising:

identifying, on said wireless network, a vehicle computer integrated with a vehicle in proximity to said vehicle wheel alignment system; and

transferring, on said wireless network, information from said vehicle computer to said vehicle wheel alignment

system in response to one or more requests for information from said vehicle wheel alignment system.

14. A method for transferring information in a vehicle wheel alignment system in communication with a wireless network, comprising:

identifying, on said wireless network, a vehicle computer associated with a vehicle in proximity to said vehicle wheel alignment system;

transferring, on said wireless network, information from said vehicle computer to said vehicle wheel alignment system in response to one or more requests for information from said vehicle wheel alignment system;

performing, with said vehicle wheel alignment system, one or more service procedures on said identified automotive vehicle;

transferring, on said wireless network, information from said vehicle wheel alignment system to said vehicle computer subsequent to a completion of said one or more service procedures on said identified automotive vehicle; and

storing said information in said vehicle computer.

15. The method of claim 14 for transferring information in a vehicle wheel alignment system further comprising the step of:

operatively coupling said vehicle computer to at least one removable transceiver configured for wireless communication with said wireless network prior to identifying said vehicle computer on said wireless network.

16. The improved vehicle wheel alignment system of claim 1 wherein said external device is a portable computing device.

17. The improved vehicle wheel alignment system of claim 1 wherein said external device is a vehicle parts inventory system.

18. The improved vehicle wheel alignment system of claim 1 wherein said external device is a vehicle service shop management system.

19. The improved vehicle wheel alignment system of claim 1 wherein said external device is an automotive lift rack.

20. A vehicle wheel alignment system including a computing device, a display, and at least one wheel alignment sensor configured to communicate wheel alignment information to the computing device, comprising:

a wireless transceiver operatively coupled to said computing device, said wireless transceiver configured to identify, on a wireless communications network, a vehicle computer of an automotive vehicle in proximity to said vehicle wheel alignment system; and

wherein the computing device is configured to utilize said wireless transceiver to communicate, via said wireless network, with said identified vehicle computer.

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,754,562 B2
DATED : June 22, 2004
INVENTOR(S) : Timothy A. Strege et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 8,

Line 27, after "unit;," remove "and".


Line 63, after "Home", replace "RE" with -- RF --.

Column 9,

Lines 41 and 42, after "vehicle", remove "electronic control module".

Signed and Sealed this

Ninth Day of May, 2006

A handwritten signature in black ink on a light gray dotted background. The signature reads "Jon W. Dudas" in a cursive style.

JON W. DUDAS

Director of the United States Patent and Trademark Office