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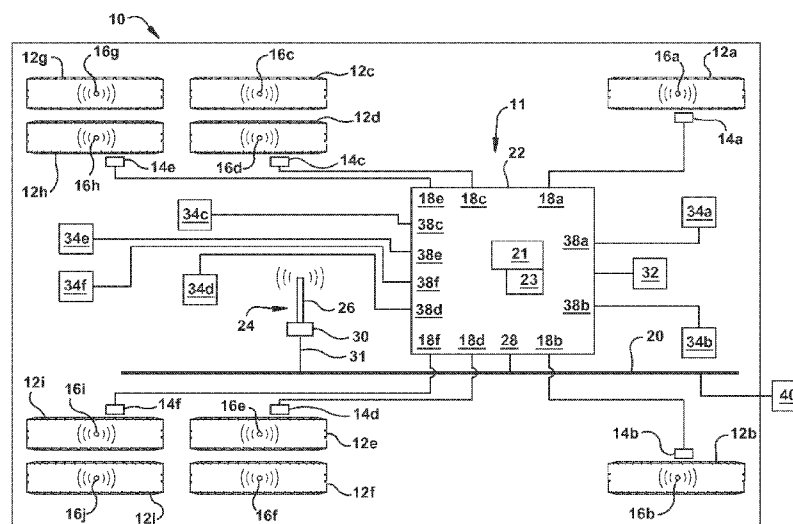
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(54) **Title:** APPARATUS AND METHOD FOR CONFIGURING A TIRE SENSOR SYSTEM**Figure 1**

(57) **Abstract:** Various embodiments of an apparatus and method for configuring a tire sensor system are disclosed. In one embodiment, the method begins with rotating a plurality of tires on a vehicle. The tire sensor associated with a first wheel location generates a data transmission in response to the rotation of the plurality of tires, the data transmission comprising at least a unique sensor identification and a motion value. The controller transmits a brake control device control signal in a first predetermined event sequence to a first brake control device associated with the first wheel location. The controller receives the tire characteristic signal and assigns the unique sensor identification with, the first wheel, location in response to determining the motion value of the tire characteristic signal corresponds with the first predetermined event sequence.



APPARATUS AND METHOD FOR CONFIGURING A TIRE SENSOR SYSTEM

Background

[0001] The present invention relates to embodiments of an apparatus and method for configuring a tire sensor system. Tire sensor systems for vehicle, for example tire pressure monitoring systems, typically include at least one tire pressure sensor in each of the plurality of tires. The tire pressure sensors communicate tire pressure signals wirelessly with a central controller on the vehicle. The wheel from which the tire pressure sensor signal is originating must be identified to indicate properly to the driver or technician which tire is in need of service. One method commonly used to associate a tire pressure sensor with the wheel location in which it is installed is by manually updating the central controller with the tire pressure sensor unique identification code (ID) when the tire with the tire pressure sensor is installed on the vehicle. This method requires time and effort from a trained technician who has the means to activate the tire pressure sensor to obtain the unique ID and then communicate with the central controller.

[0002] Trucks and/or tractors typically have at least six tires in which tire pressure sensors are installed. The tires are installed on the truck as one of the last items during an assembly line operation at an original equipment manufacturer. It is a time consuming activity to manually activate each tire pressure sensor to obtain the unique ID and then access the central controller to associate the unique ID with the wheel location in which the tire pressure sensor is installed. Often there is limited time available to add another step to the process. Likewise, whenever a tire is replaced, the central controller needs to be manually updated to associate the new tire pressure sensor unique ID with the proper wheel location.

Summary

[0003] Various embodiments of a controller for a tire sensor system are disclosed. In accordance with one aspect, a controller comprises a plurality of brake control device ports for transmitting control signals, each of the brake control device ports correlated with a specific wheel location, a communication port for receiving a data transmission from each of a plurality of tire sensors, wherein the data transmissions from each of the plurality of tire sensors includes a unique sensor identification and a motion value; and a processing unit comprising control logic, wherein the processing unit is in communication with the plurality of brake control device ports and the communication port. The control logic is capable of transmitting control signals in a predetermined event sequence to a first brake control device port associated with a first wheel location; receiving a data transmission at the communication port including a first unique sensor identification and a first motion value within a predetermined time period of transmitting the control signal; determining the data transmission as originating from the first wheel location when the first motion value corresponds to the predetermined event sequence; and assigning the first unique sensor identification to the first wheel location.

[0004] In accordance with another aspect, a method for configuring a tire sensor system comprises rotating a plurality of tires on a vehicle to a constant speed. A controller transmits a brake device control signal conforming to a first predetermined event sequence to a first brake control device associated with the first wheel location. The first tire sensor generates a data transmission in response to the brake device control signal; the data transmission includes a first unique sensor identification and a first acceleration value. The controller receives the data transmission and assigns the first unique sensor identification with the first wheel location in response to determining that the acceleration value of the tire characteristic signal corresponds with the first predetermined event sequence.

[0005] Another embodiment of a method for configuring a tire sensor system comprises rotating a plurality of tires on a vehicle to a constant speed. A controller transmits a brake

device control signal conforming to a first predetermined event sequence to a first brake control device associated with the first wheel location. The first tire sensor generates a data transmission in response to the brake device control signal; the data transmission includes a first unique sensor identification and a first acceleration value. The controller receives the data transmission and assigns the first unique sensor identification with the first wheel location in response to determining that the acceleration value of the tire characteristic signal corresponds with the first predetermined event sequence. Then the controller receives a first wheel speed signal at a first wheel speed port at the controller and determines if the data transmission originates from the first wheel location when the first wheel speed signal corresponds to the predetermined event sequence. The controller verifies the first unique sensor identification is assigned to the first wheel location based on the wheel speed signal.

[0006] In accordance with another aspect, a system for configuring a tire sensor system on a vehicle comprises a plurality of wheel speed sensors, wherein each of the plurality of wheel speed sensors is associated with a respective wheel location on a vehicle and a plurality of tire sensors, wherein each of the plurality of tire sensors is associated with a respective wheel location on the vehicle and each of the plurality of tire sensors capable of transmitting a data transmission. The system also comprises a wireless receiver for receiving the plurality data transmissions; a serial communications bus in communication with the wireless receiver and a controller; and the controller. The controller comprises a plurality of brake device output ports; a communication port in communication with the serial communication bus and a processing unit comprising control logic. The control logic communicates with the plurality of brake device ports and the communication port, the control logic capable of transmitting a brake device control signal in a first predetermined event sequence to a first brake control device associated with the first wheel location; receiving a data transmission from a first tire sensor; and associating the first tire characteristic sensor with the first wheel location in response to determining that the acceleration information of the tire characteristic signal corresponds with the first predetermined event sequence.

Brief Description of the Drawings

[0007] In the accompanying drawings which are incorporated in and constitute a part of the specification, embodiments of the invention are illustrated, which, together with a general description of the invention given above, and the detailed description given below, serve to exemplify the embodiments of this invention.

[0008] **FIGURE 1** illustrates a schematic representation of a tire sensor system according to an embodiment of the present invention.

[0009] **FIGURE 2** illustrates a method of implementing the tire sensor system, according to an embodiment of the present invention.

[0010] **FIGURE 3** illustrates another method of implementing the tire sensor system, according to an embodiment of the present invention.

Detailed Description

[0011] With reference to **FIGURE 1**, a vehicle **10** with a tire sensor system **11** is illustrated, according to an embodiment of the present invention. The vehicle **10**, a tractor or a truck, generally has at least six wheel locations and at least six tires. The wheel locations include right front, right mid, right rear, left front, left mid and left rear. The right mid, right rear, left mid and left rear wheel locations include an inner and an outer wheel location if dual tires are placed at these locations. A sample tire placement is illustrated in Figure 1 with tire **12a** at the left front, tire **12b** at the right front, tire **12c** at the outer left mid, tire **12d** at the inner left mid, tire **12e** at the inner right mid, tire **12f** at the outer right mid, tire **12g** at the outer left rear, tire **12h** at the inner left rear, tire **12i** at the inner right rear, and tire **12j** at the outer right rear. Additional or fewer tires are contemplated.

[0012] Each tire in the tire sensor system 11 includes a tire sensor, illustrated by tire sensors 16a, 16b, 16c, 16d, 16e, 16f, 16g, 16h, 16i, 16j. The tire sensor 16a, 16b, 16c, 16d, 16e, 16f, 16g, 16h, 16i, 16j can be mounted inside the respective tires 12a, 12b, 12c, 12d, 12e, 12f, 12g, 12h, 12i, 12j on the rim or outside the tires on a valve stem. The tire sensors 16a, 16b, 16c, 16d, 16e, 16f, 16g, 16h, 16i, 16j monitor tire characteristic information, such as the tire pressure, tire temperature, sensor battery voltage, vehicle load and tire vibration. The tire sensors can include an accelerometer or centrifugal switch to indicate a motion value, such as rotation of the wheel. The tire sensors 16a, 16b, 16c, 16d, 16e, 16f, 16g, 16h, 16i, 16j can be tire sensors, for example, used in the Smartire® Tire Pressure Monitoring System from Bendix Commercial Vehicle Systems LLC, of Elyria, Ohio. Each tire sensor 16a, 16b, 16c, 16d, 16e, 16f, 16g, 16h, 16i, 16j comprises a wireless transmitter that periodically transmits signals containing the tire and sensor related information and a unique sensor identification code (ID) in a selected data transmission format. The format of the signal can be a standard or a proprietary radio frequency (RF) protocol. The tire sensors 16a, 16b, 16c, 16d, 16e, 16f, 16g, 16h, 16i, 16j can also be configured to transmit data transmission upon rotation of the tire or when there is a tire pressure alert event. In one embodiment, the tire sensor transmits a data transmission every three seconds when the acceleration value changes.

[0013] The tire sensor system 11 optionally includes a wireless receiver 24. The wireless receiver 24 includes an antenna 26, a processing unit 30 and a communication port 31. The wireless receiver 24 receives the data transmissions in the selected data format containing the unique sensor ID from the tire sensors 16a, 16b, 16c, 16d, 16e, 16f, 16g, 16h, 16i, 16j wirelessly. The signals also include a motion value and a tire pressure value. The wireless receiver 24 decodes the tire characteristic information from the selected data transmission format to a tire characteristic message capable of being communicated on a serial communication bus 20. The format of the tire characteristic message may be a standard protocol, such as SAE J1939, or a proprietary protocol. The wireless receiver 24 is

capable of communicating at least one tire characteristic message over the serial communication bus **20** via the communication port **31**. The tire characteristic message can include, but is not limited to, information such as the instantaneous tire pressure, the comparison of the tire pressure against a tire pressure limit, motion value and the unique sensor ID, for example.

[0014] The vehicle **10** includes a wheel speed sensor **14a, 14b, 14c, 14d, 14e, 14f** at each wheel location. Each wheel speed sensor **14a, 14b, 14c, 14d, 14e, 14f** monitors the wheel speed at the wheel location. There can be fewer wheel speed sensors or a wheel speed sensor for each tire when more than one tire is located at a wheel location, such as with dual tire installations.

[0015] The vehicle **10** includes a brake control device **34a, 34b, 34c, 34d, 34e, 34f** at each wheel location. Each brake control device **34a, 34b, 34c, 34d, 34e, 34f** is used for anti-lock braking and/or stability control. There can be a single brake control device or a brake control device for each tire when more than one tire is located at a wheel location, such as with dual tire installations. In one example, the brake control device is an antilock brake control modulator. In another example, the brake control device is an electropneumatic device.

[0016] The tire sensor system **11** includes a controller **22**. The controller **22** can be a stand-alone controller or include functionality for controlling the antilock braking system in addition to tire pressure monitoring. The brake control devices **34a, 34b, 34c, 34d, 34e, 34f** receive control signals from the controller **22** from a plurality of brake control device ports **38a, 38b, 38c, 38d, 38e, 38f** on the controller **22**. The brake control devices receive an air supply from either the application of the brake treadle (not shown) by the driver or from a valve (not shown) that is independently controlled by the controller **22** to provide supply pressure independent of the driver's brake application.

[0017] As shown in Figure 1, the brake control device port **38a** is associated with the brake control device **34a**, which is located at the left front wheel location. Similarly brake

control device port **38b** is associated with brake control device **34b**, which is located at the left front wheel location, etc. The wiring for vehicle **10** is configured so that the brake control device **34a** located at the left front wheel end section is connected to the brake control device port **38a** on the controller. A vehicle may be configured with six brake control devices or four brake control devices or other number depending on the braking systems installed on the vehicle.

[0018] The wheel speed sensors **14a, 14b, 14c, 14d, 14e, 14f** communicate wheel speed to the controller **22** via a hard-wired connection through individual wheel speed ports **18a, 18b, 18c, 18d, 18e, 18f** on the controller **22**. As shown in Figure 1, wheel speed port **18a** is associated with the wheel speed sensor **14a**, which is located at the left front wheel location. Similarly wheel speed port **18b** is associated with wheel speed sensor **14b**, which is located at the left front wheel location, etc. Similar to the brake control devices, the wiring for vehicle **10** is configured so that the wheel speed sensor **14a** located at the left front wheel end section is connected to wheel speed port **18a** on the controller. Alternatively, the wheel speed information is received via another means, such as over the serial communication bus **20** or via a wireless receiver, in addition to or instead of a hard-wired connection.

[0019] The controller **22** includes a communication port **28** for communicating with the serial communication bus **20** on the vehicle **10**. Controller **22** may communicate with other controllers on the vehicle **10** using the serial communication bus **20**. The messages received and transmitted on the bus can be in a standardized serial communication bus format, such as SAE J1939, or in a proprietary format.

[0020] The controller **22** includes a processing unit **21**. The processing unit **21** includes control logic **23** and is in communication with the plurality of brake control device ports **38a, 38b, 38c, 38d, 38e, 38f**, the plurality of wheel speed sensor ports **18a, 18b, 18c, 18d, 18e, 18f** and the communication port **28**. The processing unit **21** may include volatile, non-volatile memory, solid state memory, flash memory, random-access memory (RAM),

read-only memory (ROM), electronic erasable programmable read-only memory (EEPROM), variants of the foregoing memory types, combinations thereof, and/or any other type(s) of memory suitable for providing the described functionality and/or storing computer-executable instructions for execution by the processing unit.

[0021] The control logic 23 is capable of transmitting control signals to the brake control device ports 38a, 38b, 38c, 38d, 38e, 38f to control the brake control devices 34a, 34b, 34c, 34d, 34e, 34f. The control signals are transmitted in a predetermined event sequence, as described further below.

[0022] The control logic 23 receives messages from the serial communication bus 20 via the communication port 28. The messages include tire characteristic messages as transmitted on the serial communication bus 20 from the wireless receiver 24. The control logic 23 also transmits messages to the serial communication bus 20 via the communication port 28. The transmitted messages include the tire characteristic messages with associated wheel location and the wheel speed.

[0023] In alternative embodiment the wireless receiver 24 is integrated with the controller 22. In this arrangement, the control logic 23 of the controller 22 decodes the data in the tire characteristic signals directly from the antenna 26 rather than monitor the serial communication bus 20 for the separate tire characteristic messages.

[0024] The tire sensor system 11 optionally includes a display device 32. The display device may be connected with the controller 22 or to the serial communication bus 20. The display device 32 communicates the status of the tire sensor system 11 to a vehicle operator or technician. Optionally, the control logic 23 can record a fault and transmit a fault signal directly to the display device 32 or via the serial communication bus 20.

[0025] Optionally, a computing device 40 located separately from the tire sensor system 11 may be connected to the serial communication bus 20. The computing device 40 stores the tire characteristic messages and creates a build log. The build log associates each

tire with a specific tire sensor in a format usable by the vehicle original equipment manufacturer as the tire sensor system **11** is configured.

[0026] As stated previously, there is a need for an improved system to configure a tire pressure monitoring system for tractors and trucks so each tire sensor is quickly and accurately assigned to the wheel location where it is installed. The method of configuring the tire pressure monitoring system does not require a separate download of sensor identification numbers to the central controller or additional tools such as sensor initiators. The method can also be used to identify tire sensor locations on other multi-wheeled vehicles, such as trailers.

[0027] Accordingly, in an embodiment of the present invention, the controller comprises a plurality of brake control device ports for transmitting control signals, each of the brake control device ports is correlated with a specific wheel location; a communication port for receiving data transmissions from a plurality of tire sensors, wherein the data transmissions includes a unique sensor identification and a motion value; and a processing unit comprising control logic, wherein the processing unit is in communication with the plurality of brake control device ports and the communication port. The control logic is capable of transmitting control signals in a predetermined event sequence to a first brake control device port associated with a first wheel location; receiving a data transmission at the communication port including a first unique sensor identification and a first motion value within a predetermined time period of transmitting the control signal; determining the data transmission as originating from the first wheel location when the first motion value corresponds to the predetermined event sequence and assigning the first unique sensor identification to the first wheel location.

[0028] A flowchart for implementing a method **50** of the present invention is shown in **FIGURE 2**. Prior to the implementation of the method **50**, each tire **12a**, **12b**, **12c**, **12d**, **12e**, **12f**, **12g**, **12h**, **12j** is placed at a specific wheel location on the vehicle. Alternatively, one tire can be placed at a specific wheel location at a time and the method executed in a

predetermined sequence. Each tire **12a, 12b, 12c, 12d, 12e, 12f, 12g, 12h, 12j** has a tire sensor **16a, 16b, 16c, 16d, 16e, 16f, 16g, 16h, 16i, 16j** installed. For the present illustration, tire **12a** is located on the left front wheel end section of the vehicle. Tire **12b** is located on the right front wheel end section of the vehicle. Tire **12c** is located at the outer left mid wheel location and **12d** is located at the inner left mid wheel end section. Tire **12e** is located at the inner right mid wheel location and **12f** is located in the outer right mid wheel location. Tire **12g** is located at the outer left rear wheel location and **12h** is located in the inner left rear wheel location. Tire **12i** is located at the inner right rear wheel location and **12j** is located at the outer right rear section of the vehicle. The tire placement is done by a vehicle original equipment manufacturer or by a technician servicing the vehicle. At this point, the controller **22** does not have information regarding the placement of the tires **12a, 12b, 12c, 12d, 12e, 12f, 12g, 12h, 12j** at a specific wheel location.

[0029] The vehicle **10** is then placed on a test device, such as a chassis dynamometer from Link Engineering of Plymouth Michigan. The dynamometer is a device that allows a vehicle to be tested while running at a chosen speed, but keeps the vehicle stationary. Dynamometers are typically used by vehicle original equipment manufacturers for end of line testing of vehicles. The tires **12a, 12b, 12c, 12d, 12e, 12f, 12g, 12h, 12i, 12j** can be rotated by a dynamometer or other an automated rotation device. Alternatively, the vehicle **10** can be place in a test mode by the vehicle operator during normal operation of the vehicle **10**.

[0030] In step **52** of method **50**, the vehicle **10** on which the tire sensor system **11** is to be configured has the tires rotated at a predetermined speed. The tires should be rotated for a minimum of about fifteen seconds at a speed of about three miles per hour. The tires can be rotated in pairs, such as tires **12a, 12b** on the front axle being rotated separately from the tires **12c, 12d, 12e, 12f, 12g, 12h, 12i, 12j** on the rear axle. The method **50** determines if the wheels are at a constant speed in step **54**. In other words, all of the wheels are running at the same speed for a period of time. The speed of the tires can be determined using the wheel speed sensors **14a, 14b, 14c, 14d, 14e, 14f** or other means. When at constant speed,

the motion value sensed by any tire sensor is zero. When the vehicle **10** is at constant speed, the method proceeds to step **56**. If the vehicle **10** is not at constant speed, the method returns to step **52**.

[0031] In step **56**, the controller **22** sends a brake control device control signal to a single brake control device output port. For example, the controller **22** sends a brake control device control signal to the brake control device output port **38a** to control the brake control device **34a** on the left front wheel location. The controller **22** sends a single control signal or sends multiple control signals in a predetermined event sequence. The predetermined event sequence may be different for each wheel location or may be consistent for each wheel location. In one example, the control signal is sent as a pulse width modulated format. Each time the brake control device **34a** receives a brake control signal, the brake control device **34a** responds by opening and closing a pathway for air to reach the brake at the wheel end. When supply air is at the brake control device **34a** and the brake control device **34a** opens to provide air to the wheel end brake assembly, the brake control device **34a** induces deceleration at the wheel end to which it is connected. The controller **22** monitors the time at which the controller **22** sent the control signal.

[0032] The controller **22** monitors for tire characteristic messages in step **58**. When braking is induced at a wheel end, the motion value of the tire sensor in that particular wheel end will change in response to the deceleration that occurs. In one example, the tire sensor transmits a data transmission when the motion value changes in response to the deceleration. For example, a tire sensor will transmit a data transmission every three seconds when there is a change in the motion value. In another example, the tire sensor will periodically transmit a data transmission every five minutes when there is no change in the motion value or tire pressure value. In the tire sensor system **11** that includes a wireless receiver **24**, the data transmissions are formatted into a tire characteristic message at the wireless receiver **24**. When the controller **22** receives a tire characteristic message at the communication port **28**, the controller **22** analyzes the tire characteristic message for a motion value.

[0033] If no tire characteristic message is received within a predetermined time period after the brake control signal is transmitted, the controller **22** will indicate that there is a fault in the tire sensor system **11** and discontinue the method **50**. In one embodiment, the predetermined time period is between about five seconds and about fifteen seconds. In another embodiment, the predetermined time period is about ten seconds.

[0034] In step **60**, the message is evaluated for the value of the motion value, which generally indicates a change in acceleration. The acceleration information is compared to the predetermined event sequence. In one example, a predetermined event sequence of three short brake control signals in a row induces three deceleration events at the wheel end to which the brake control device is connected. The other wheel ends will have zero change in acceleration because the dynamometer continues to run at constant speed and no deceleration is induced at those wheel ends since there is no brake control signal transmitted to the brake control devices associated with those wheel ends. Therefore, the control logic **23** determines that a tire message with a motion value other than zero is from the tire sensor in the wheel being decelerated in response to the brake control signal since the change in the motion value corresponds with predetermined event sequence.

[0035] In addition, for a dual tire installation, a positive acceleration and negative acceleration on the complementary tires occurs. When dual tires are installed, the tire sensors are identified by rim style so that the tire sensor for the inner tire will show acceleration in the positive direction and the tire sensor for the outer tire will show negative acceleration when the tires are rotated. For example, on the left rear tires **12g**, **12h**, the inner tire **12h** has a positive installation and the outer tire **12g** has a negative installation. When the left rear tires **12g**, **12h** are rotated and subsequently the brake control signal is transmitted to brake control device to **34e**, tire sensors **16h**, **16g** experience a change in acceleration for which the tire sensor **16h** exhibit positive acceleration and the tire sensor **16g** will exhibit negative acceleration. If the acceleration is zero, the method returns to step **58** to monitor for additional tire characteristic messages.

[0036] In step 62, the controller 22 assigns the unique sensor ID of the tire sensor that was activated by the deceleration induced by the brake control device with the wheel location associated with the brake control device. The unique sensor ID will remain assigned to that wheel end until the method 50 is run again.

[0037] The method 50 continues with step 64 where the controller 22 determines if all wheel ends have been assigned to a particular tire sensor. If not, the routine returns to step 52. If all of the wheel ends have been assigned to a particular tire sensor, the method ends at step 66.

[0038] A flowchart for implementing another method 80 of the present invention is shown in FIGURE 3. Similar to the beginning of the method 50, each tire 12a, 12b, 12c, 12d, 12e, 12f, 12g, 12h, 12j is placed at a specific wheel location on the vehicle. At this point, the controller 22 does not have information regarding the placement of the tires 12a, 12b, 12c, 12d, 12e, 12f, 12g, 12h, 12j at a specific wheel location.

[0039] For the first step in method 80, the tires are rotated to a predetermined speed. For example, the tires can be rotated for a minimum of about fifteen seconds at a speed of about three miles per hour. The tires can be rotated in pairs, such as 12a, 12b on the front axle, or all of the tires 12a, 12b, 12c, 12d, 12e, 12f, 12g, 12h, 12i, 12j can be rotated at one time. The method 80 determines if the wheels are at a constant acceleration in step 84. In other words, all of the wheels are running at the same speed for a period of time. The acceleration of the tires can be determined using the wheel speed sensors or other means. If the vehicle is not at constant speed, the method returns to step 82. When at substantially constant acceleration, the motion value sensed by each tire sensor is zero. When the vehicle 10 is at constant speed, the method proceeds to step 86.

[0040] In step 86, the controller 22 sends a brake control device control signal to a single brake control device output port. For example, the controller 22 sends a brake control device control signal to brake control device output port 38a to control the brake control device 34a on the left front wheel location. The controller 22 sends a single control signal or

sends multiple control signals in a predetermined event sequence. In one example, the control signal may be sent as a pulse width modulated format. The brake control device **34a** responds by opening and closing a pathway for air to reach the brake at the wheel end. When supply air is at the brake control device, the brake control device will induce braking at the wheel end to which it is connected. The controller **22** monitors the time at which the controller **22** sent the control signal.

[0041] The controller **22** monitors for a tire characteristic message in step **88**. When braking is induced at a wheel end, the motion value of the tire sensor in that particular wheel end will change in response to the deceleration that occurs. In one example, the tire sensor transmits a data transmission when motion occurs. When the controller **22** receives a tire characteristic message at the communication port **28**, the controller **22** analyzes the tire characteristic message for a motion value. If no tire characteristic message is received within a predetermined time period after the brake control signal is transmitted, the controller **22** will indicate that there is a fault in the tire sensor system **11** and either return to step **88** or discontinue method **80**. In one embodiment, the predetermined time period is between about five seconds and about fifteen seconds. In another embodiment, the predetermined time period is about ten seconds.

[0042] In step **92**, the wheel speed sensors **14a, 14b, 14c, 14d, 14e, 14f** are monitored. The wheel speed at a wheel will also change in response to induced braking. When the tire characteristic message includes a change in the motion value, indicating a change in acceleration, the motion value is compared to the change in the wheel speed at the particular wheel. If the change in wheel speed correlates with the induced braking, the controller **22** assigns the tire sensor unique ID to that wheel end.

[0043] The method **80** continues with step **98** where the controller **22** determines if all wheel ends have been assigned to a particular tire sensor. If not, the routine returns to step **82**. If all of the wheel ends have been assigned to a particular tire sensor, the method ends at step **100**.

[0044] Accordingly, a method for configuring a tire sensor system is disclosed. The method begins with rotating a plurality of tires on a vehicle. The tire sensor associated with a first wheel location generates a tire characteristic signal in response to the rotation of the plurality of tires, the tire characteristic signal comprising a unique sensor identification and a motion value, for example, acceleration information. The controller transmits a brake control device control signal conforming to a first predetermined event sequence to a first brake control device associated with the first wheel location. The controller receives the tire characteristic signal, and assigns the unique sensor identification with the first wheel location in response to determining the acceleration information of the tire characteristic signal corresponds with the first predetermined event sequence.

[0045] While the present invention has been illustrated by the description of embodiments thereof, and while the embodiments have been described in considerable detail, it is not the intention of the applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the invention, in its broader aspects, is not limited to the specific details, the representative apparatus, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of the applicant's general inventive concept.

We claim:

1. A controller comprising:

a plurality of brake control device ports for transmitting control signals, each of the brake control device ports correlated with a specific wheel location;

a communication port for receiving a data transmission from each of a plurality of tire sensors, wherein the data transmissions from each of the plurality of tire sensors includes a unique sensor identification and a motion value; and

a processing unit comprising control logic, wherein the processing unit is in communication with the plurality of brake control device ports and the communication port, the control logic capable of:

transmitting control signals in a predetermined event sequence to a first brake control device port associated with a first wheel location;

receiving a data transmission at the communication port from a first tire sensor including a first unique sensor identification and a first motion value within a predetermined time period of transmitting the control signal;

determining the data transmission as originating from the first wheel location when the first motion value corresponds to the predetermined event sequence; and

assigning the first unique sensor identification to the first wheel location.

2. The controller as in claim 1, further comprising:

a plurality of wheel speed ports for receiving wheel speed sensor signals, each of the plurality of wheel speed ports correlated with a specific wheel location, wherein the processing unit is in communication with the plurality of wheel speed ports; and

the control logic is capable of:

receiving a signal indicative of a wheel speed at a first wheel speed port corresponding with a first wheel location;

determining the data transmission as originating from the first wheel location when the wheel speed signal corresponds to the predetermined event sequence; and

verifying the first unique sensor identification is assigned to the first wheel location based on the wheel speed signal.

3. The controller as in claim 1, wherein the control signal is transmitted to the first brake control device port in a first predetermined event sequence and the control signal is transmitted to a second brake control port in a second predetermined event sequence.
4. The controller as in claim 1, wherein the control logic is capable of transmitting a tire characteristic message to a serial communication bus, the message comprising the assignment of the first wheel location with the first unique sensor identification and tire characteristic information.
5. The controller as in claim 4, wherein the tire characteristic information comprises at least one of: a tire pressure, sensor battery level, tire rotation and a tire temperature.
6. The controller as in claim 4, wherein the control logic is capable of transmitting the tire characteristic message to a computing device via the serial communication device, the computing device storing the tire characteristic message and creating a build log.
7. The controller as in claim 1, wherein the predetermined time period is between about five seconds and about fifteen seconds.
8. The controller as in claim 1, wherein the controller is a braking system controller.
9. The controller as in claim 1, wherein the control logic is capable of transmitting a diagnostic trouble code to at least one of a serial communication bus and a display device when the tire characteristic message is not received within the predetermined time period.
10. The controller as in claim 1 wherein the control logic is further capable of:
 - transmitting control signals in a predetermined event sequence to a second brake control device port associated with a second wheel location;
 - receiving a data transmission at the communication port from a second tire sensor including a second unique sensor identification and a second motion value within a predetermined time period of transmitting the control signal;
 - determining the data transmission as originating from the second wheel location when the second motion value corresponds to the predetermined event sequence; and
 - assigning the second unique sensor identification to the second wheel location.
11. A method for configuring a tire sensor system comprising:
 - rotating a plurality of tires on a vehicle to a constant speed;

transmitting a brake device control signal conforming to a first predetermined event sequence to a first brake control device associated with the first wheel location;

generating a data transmission from a first tire sensor associated with a first wheel location in response to the brake device control signal, the data transmission including a first unique sensor identification and a first motion value;

receiving the data transmission at a controller; and

assigning the first unique sensor identification with the first wheel location in response to determining that the motion value of the data transmission corresponds with the first predetermined event sequence.

12. The method as in claim 11, further comprising: transmitting a tire characteristic message from the controller, the tire characteristic message comprising the assignment of the first wheel location with the first unique sensor identification and tire characteristic information.

13. The method as in claim 11, comprising transmitting a diagnostic trouble code to at least one of a serial communication bus and a display device when a predetermined time period has elapsed and the data transmission has not been received.

14. The method as in claim 13, wherein the predetermined time period is between about five seconds and about fifteen seconds.

15. The method as in claim 11 further comprising:

receiving a first wheel speed signal at a first wheel speed port at the controller, the first wheel speed port correlated with a first wheel location, and

determining the data transmission as originating from the first wheel location when the first wheel speed signal corresponds to the predetermined event sequence; and

verifying the first unique sensor identification is assigned to the first wheel location based on the wheel speed signal.

16. The method as in claim 15, wherein transmitting the brake device control signal results in a reduction of the wheel speed signal.

17. The method as in claim 11 further comprising:

transmitting a brake device control signal conforming to a second predetermined event sequence to a second brake control device associated with a second wheel location;

generating a data transmission from a second tire sensor associated with the second wheel location in response to the brake device control signal, the data transmission including a second unique sensor identification and a second motion value within a predetermined time period of transmitting the control signal; and

assigning the second unique sensor identification to the second wheel location in response to determining that the motion value of the data transmission corresponds to the second predetermined event sequence.

18. A system for configuring a tire sensor system on a vehicle comprising:

a plurality of wheel speed sensors, wherein each of the plurality of wheel speed sensors is associated with a respective wheel location on a vehicle;

a plurality of tire sensors, wherein each of the plurality of tire sensors is associated with a respective wheel location on the vehicle and each of the plurality of tire sensors capable of transmitting a data transmission;

a plurality of brake control devices, wherein each of the plurality of brake control devices is associated with a respective wheel location on the vehicle;

a wireless receiver for receiving the plurality data transmissions;

a serial communications bus in communication with the wireless receiver and a controller; and

the controller comprising;

a plurality of brake control device output ports;

a communication port in communication with the serial communication bus;

a processing unit comprising control logic, the control logic communicating with the plurality of brake device ports and the communication port, the control logic capable of transmitting a brake control device control signal conforming to a first predetermined event sequence to a first brake control device associated with the first wheel location; receiving a data transmission from a first tire sensor; and associating the first tire characteristic sensor with the first wheel location in response to determining that the

acceleration information of the tire characteristic signal corresponds with the first predetermined event sequence.

19. The system as in claim 18, wherein the wireless receiver is integral to the controller.

20. The system as in claim 18 wherein the tire characteristic signal comprises at least one of: a sensor identification number, acceleration information, a tire pressure and a tire temperature.

21. The system as in claim 18, wherein the brake control device is an antilock brake modulator.

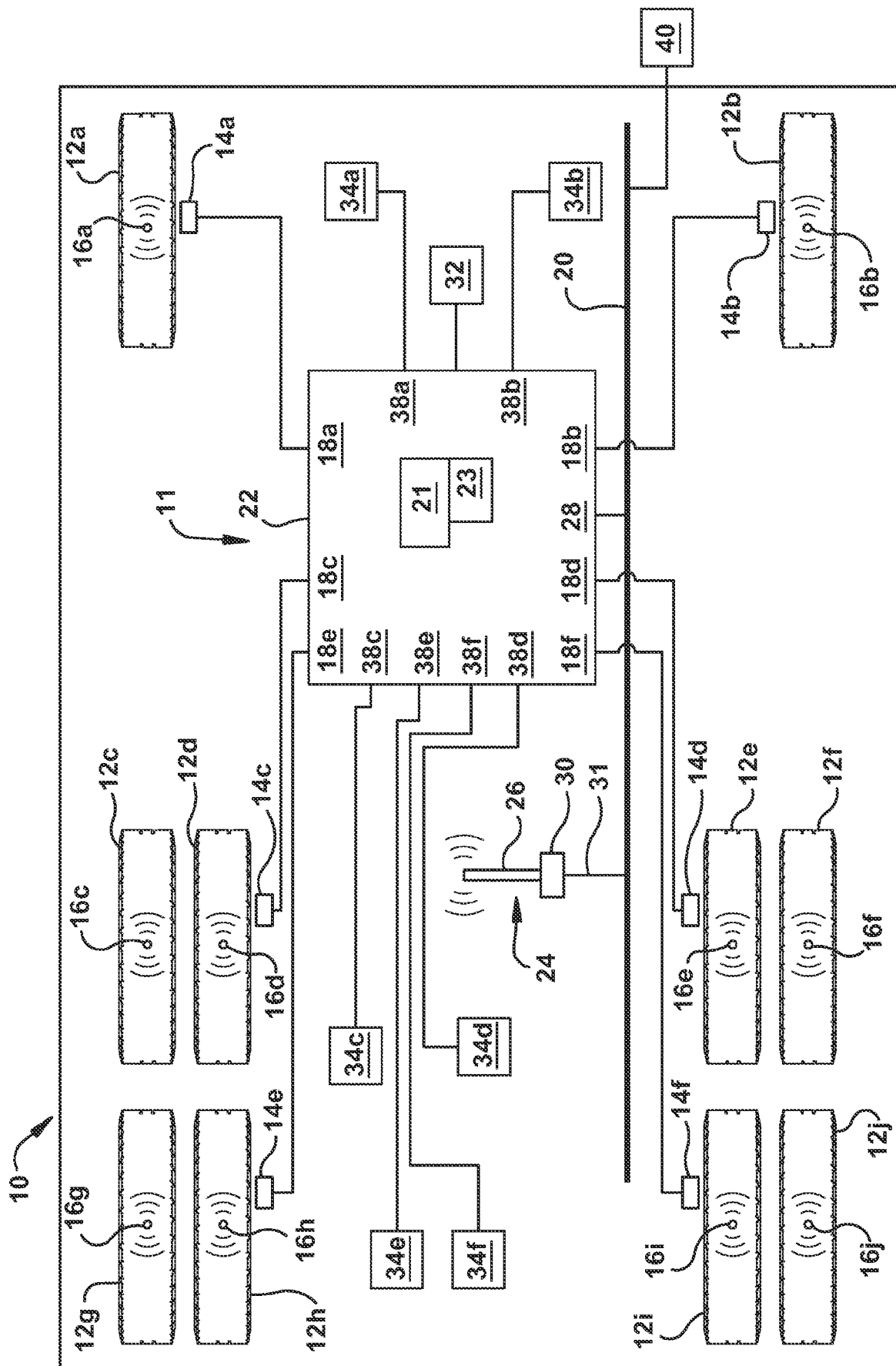
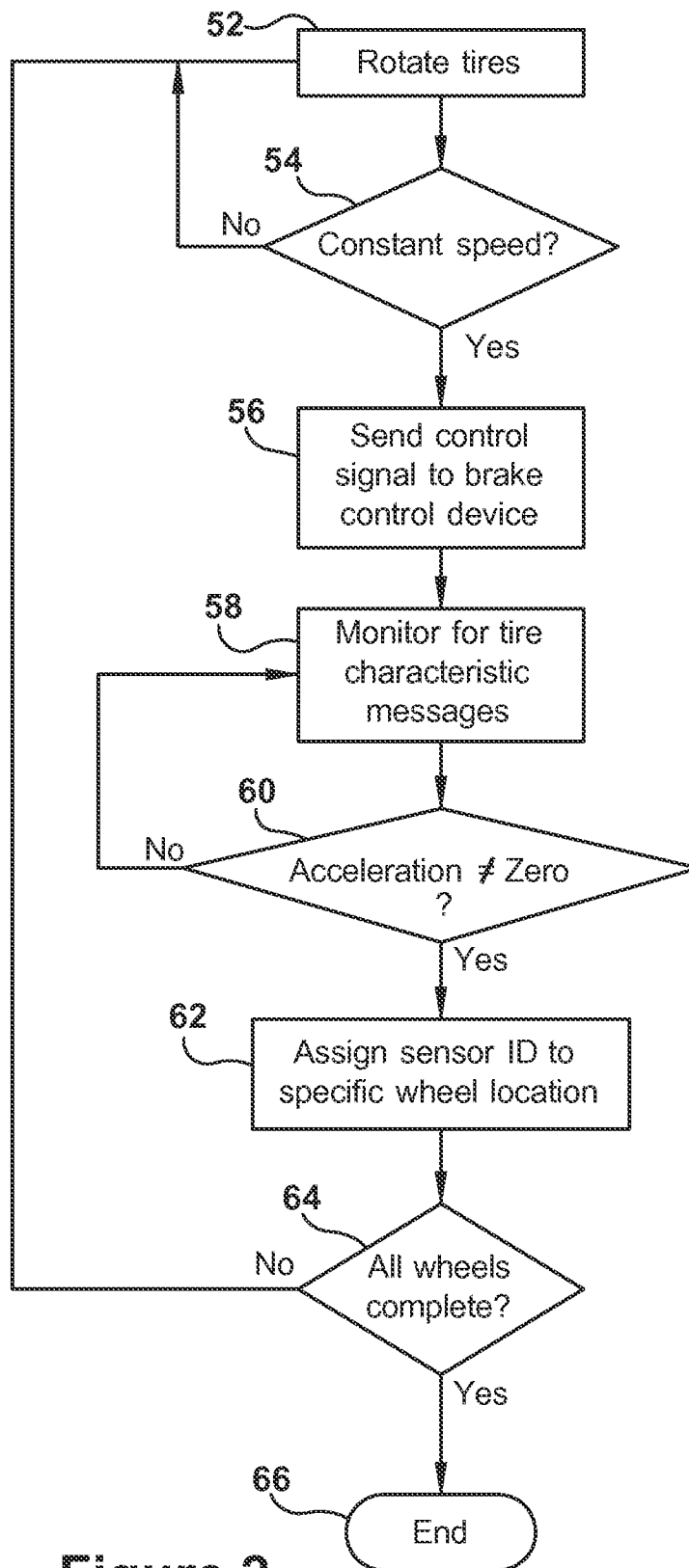
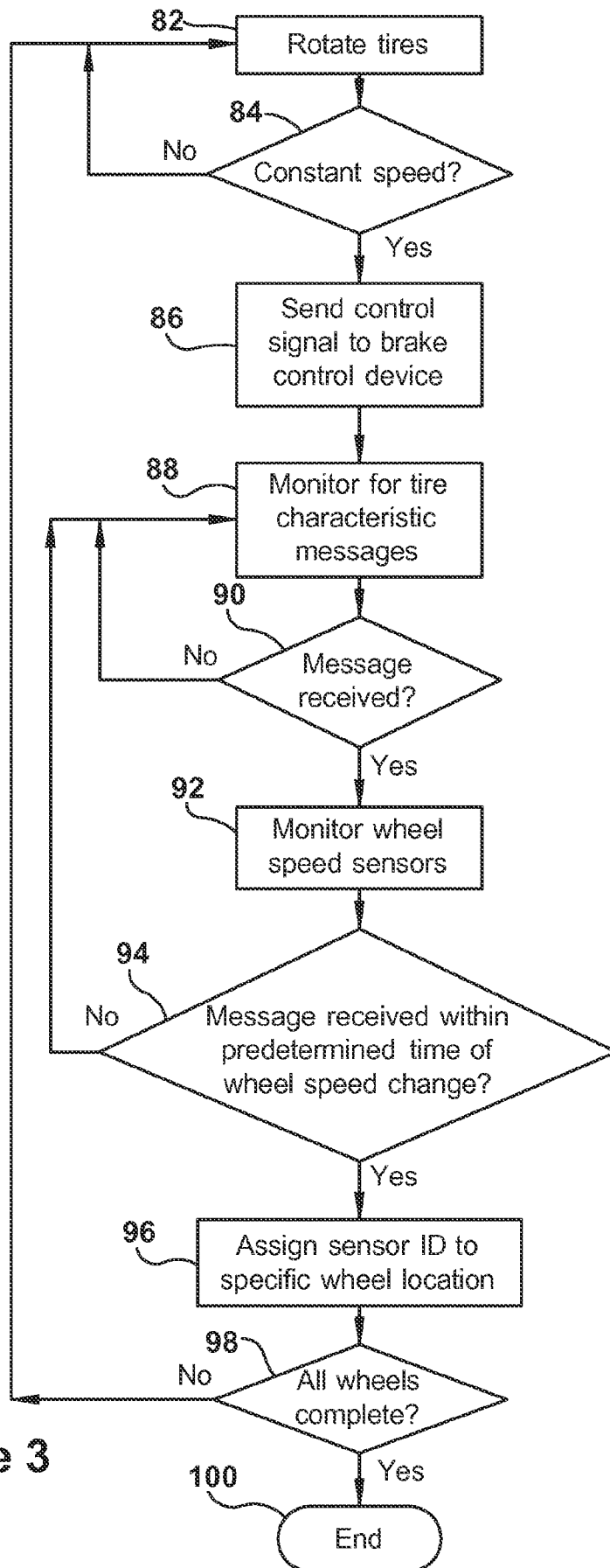


Figure 1

**Figure 2**

**Figure 3**

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2015/039946

A. CLASSIFICATION OF SUBJECT MATTER

INV. B60C23/04 B60C23/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2010 037512 A1 (BORGWARNER BERU SYSTEMS GMBH [DE]) 1 March 2012 (2012-03-01) abstract paragraph [0008] - paragraph [0017]; claim 1	1-21
X	FR 2 831 102 A1 (SIEMENS AG [DE]) 25 April 2003 (2003-04-25) the whole document	1,11,18
A		2-10, 12-17, 19-21



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

8 September 2015

Date of mailing of the international search report

17/09/2015

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2015/039946

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102010037512 A1	01-03-2012	CN 102529609 A	04-07-2012
		DE 102010037512 A1	01-03-2012
		US 2012060598 A1	15-03-2012

FR 2831102 A1	25-04-2003	DE 10152338 A1	15-05-2003
		FR 2831102 A1	25-04-2003
		US 2003090372 A1	15-05-2003
