(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 December 2010 (16.12.2010)

PCT

(10) International Publication Number
WO 2010/144248 A1

(51) International Patent Classification:
B64D 45/00 (2006.01)

(21) International Application Number:
PCT/US2010/036082

(22) International Filing Date:
25 May 2010 (25.05.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
12/484,151 12 June 2009 (12.06.2009) US

(71) Applicant *(for all designated States except US)*: **THE BOEING COMPANY** [US/US]; 100 North Riverside Plaza, Chicago, Illinois 60606-2016 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **LEWIS, Dennis M.** [US/US]; 14407 4TH Ave W, Lynwood, Washington 98087 (US). **GREEN, William P.** [US/US]; 410 NE 190th Pl, Shoreline, Washington 98155 (US). **BOMMER, Jason P.** [US/US]; 1723 N. Fife St, Tacoma, Washington 98406 (US).

(74) Agents: **RAD, Fariba K** et al.; The Boeing Company, P.O. Box 2515, MC 110-SD54, Seal Beach, California 90740-1515 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *as to the identity of the inventor (Rule 4.17(i))*
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:
— *with international search report (Art. 21(3))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) **Title**: METHOD AND APPARATUS FOR WIRELESS AIRCRAFT COMMUNICATIONS USING FUSELAGE STRINGERS

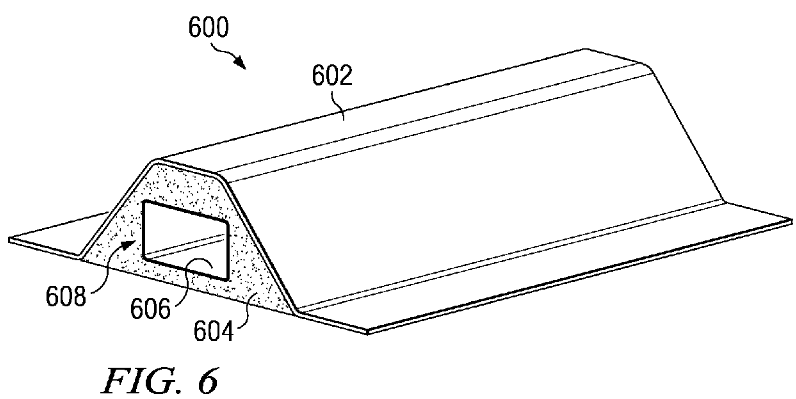


FIG. 6

(57) **Abstract**: A method and apparatus for transmitting wireless signals. An apparatus comprises a stringer (600) having a channel and a waveguide (608) located within the channel. The waveguide is capable of carrying a number of wireless signals.

WO 2010/144248 A1

METHOD AND APPARATUS FOR WIRELESS AIRCRAFT COMMUNICATIONS USING FUSELAGE STRINGERS

BACKGROUND INFORMATION

1. Field:

[0001] The present disclosure relates generally to aircraft and, in particular, to network data processing systems in aircraft. Still more particularly, the present disclosure relates to a method and apparatus for a wireless communications and power system using stringers in a network data processing system in an aircraft.

2. Background:

[0002] Aircraft contain many devices that use power and exchange information. These devices include, for example, without limitation, flight control computers, in-flight entertainment systems, line replaceable units, environmental control systems, sensors, and other suitable devices. Many of these devices may be non-critical and may require low amounts of power. Examples of these devices include a proximity sensor, a temperature sensor, an accelerometer, and/or some other suitable type of sensor. These sensors and other types of sensors may be used in a health monitoring system on an aircraft to perform health monitoring of the aircraft.

[0003] The sensors in a healthmonitoring system may monitor various conditions during the operation of an aircraft. For example, sensors monitor temperatures of various devices, vibrations, force, and/or other relevant conditions. This information is sent to a line replaceable unit or other type of data processing system in the health monitoring system. The information is analyzed to identify maintenance needs for the aircraft. As a result, these types of sensors add benefits including condition-based maintenance and increased safety.

[0004] Implementing a health monitoring system in an aircraft involves additional wiring used to provide the exchange of information and power between different devices in the health monitoring system. The wiring for a health monitoring system adds weight, cost, and/or maintenance burdens to an aircraft. These factors may reduce performance and/or increase operating costs.

[0005] Therefore, it would be advantageous to have a method and apparatus that takes into account one or more of the issues discussed above, as well as possibly other issues.

SUMMARY

[0006] In one advantageous embodiment, an apparatus comprises a stringer having a channel and a waveguide located within the channel. The waveguide is capable of carrying a number of wireless signals.

[0007] In another advantageous embodiment, an aircraft network data processing system comprises a plurality of composite stringers and a plurality of devices. The plurality of composite stringers is attached to a skin of an aircraft and is capable of carrying a number of wireless signals. The number of wireless signals is selected from at least one of an information signal and a power signal. Each stringer in the plurality of composite stringers comprises a composite material having a first channel, foam located in the first channel and having a second channel, and a waveguide located in the second channel. The plurality of devices is associated with the plurality of composite stringers and is capable of exchanging the number of wireless signals carried in the plurality of composite stringers.

[0008] In yet another advantageous embodiment, a method is present for transmitting wireless signals in a vehicle. A number of wireless signals are transmitted from a first device into a number of waveguides located in a number of stringers in the vehicle. The number of wireless signals is carried in the number of waveguides in the number of stringers. The number of wireless signals is received from the number of waveguides at a second device.

[0009] The features, functions, and advantages can be achieved independently in various embodiments of the present disclosure or may be combined in yet other embodiments in which further details can be seen with reference to the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The novel features believed characteristic of the advantageous embodiments are set forth in the appended claims. The advantageous embodiments, however, as well as a preferred mode of use, further objectives, and advantages thereof, will best be understood by reference to the following detailed description of an advantageous embodiment of the present disclosure when read in conjunction with the accompanying drawings, wherein:

[0011] **Figure 1** is a diagram illustrating an aircraft manufacturing and service method in accordance with an advantageous embodiment;

[0012] **Figure 2** is a diagram of an aircraft in which an advantageous embodiment may be implemented;

[0013] **Figure 3** is a diagram of a network environment in accordance with an advantageous embodiment;

[0014] **Figure 4** is a diagram illustrating a portion of a fuselage of an aircraft in accordance with an advantageous embodiment;

[0015] **Figure 5** is a diagram illustrating composite stringers connected to each other in a network in accordance with an advantageous embodiment;

[0016] **Figure 6** is a diagram illustrating a cross-sectional perspective view of a hat-shaped stringer with a waveguide in accordance with an advantageous embodiment;

[0017] **Figure 7** is a diagram of a cross-sectional perspective view of a portion of a composite stringer in accordance with an advantageous embodiment;

[0018] **Figure 8** is a diagram illustrating a cross-sectional view of a waveguide with an access point in accordance with an advantageous embodiment;

[0019] **Figure 9** is a diagram of a composite stringer with a location for an access point in accordance with an advantageous embodiment;

[0020] **Figure 10** is a diagram of a data processing system in accordance with an advantageous embodiment; and

[0021] **Figure 11** is a flowchart of a process for transmitting wireless signals in a vehicle in accordance with an advantageous embodiment.

DETAILED DESCRIPTION

[0022] Referring more particularly to the drawings, embodiments of the disclosure may be described in the context of aircraft manufacturing and service method **100** as shown in **Figure 1** and aircraft **200** as shown in **Figure 2**. Turning first to **Figure 1**, a diagram illustrating an aircraft manufacturing and service method is depicted in accordance with an advantageous embodiment. During pre-production, exemplary aircraft manufacturing and service method **100** may include specification and design **102** of aircraft **200** in **Figure 2** and material procurement **104**.

[0023] During production, component and subassembly manufacturing **106** and system integration **108** of aircraft **200** in **Figure 2** takes place. Thereafter, aircraft **200** in **Figure 2** may go through certification and delivery **110** in order to be placed in service **112**. While in service by a customer, aircraft **200** in **Figure 2** is scheduled for routine maintenance and service **114,** which may include modification, reconfiguration, refurbishment, and other maintenance or service.

[0024] Each of the processes of aircraft manufacturing and service method **100** may be performed or carried out by a system integrator, a third party, and/or an operator. In these examples, the operator may be a customer. For the purposes of this description, a system integrator may include, without limitation, any number of aircraft manufacturers and major-system subcontractors; a third party may include, without limitation, any number of venders, subcontractors, and suppliers; and an operator may be an airline, leasing company, military entity, service organization, and so on.

[0025] With reference now to **Figure 2**, a diagram of an aircraft is depicted in which an advantageous embodiment may be implemented. In this example, aircraft **200** is produced by aircraft manufacturing and service method **100** in **Figure 1** and may include airframe **202** with a plurality of systems **204** and interior **206**. Examples of systems **204** include one or more of propulsion system **208**, electrical system **210**, hydraulic system **212**, environmental system **214,** and aircraft network data processing system **216**. Any number of other systems may be included. Although an aerospace example is shown, different advantageous embodiments may be applied to other industries, such as the automotive industry.

[0026] Apparatus and methods embodied herein may be employed during any one or more of the stages of aircraft manufacturing and service method **100** in **Figure 1**. For example, components or subassemblies produced in component and subassembly manufacturing **106** in **Figure 1** may be fabricated or manufactured in a manner similar to components or subassemblies produced while aircraft **200** is in service **112** in **Figure 1**.

[0027] Also, one or more apparatus embodiments, method embodiments, or a combination thereof may be utilized during production stages, such as component and subassembly manufacturing **106** and system integration **108** in **Figure 1**, for example, without limitation, by substantially expediting the assembly of or reducing the cost of aircraft **200**. Similarly, one or more of apparatus embodiments, method embodiments, or a combination thereof may be utilized while aircraft **200** is in service **112** or during maintenance and service **114** in **Figure 1**.

[0028] As an illustrative example, in one or more advantageous embodiments, an aircraft network data processing system, such as aircraft network data processing system **216,** may be implemented during system integration **108** in **Figure 1.** Aircraft network data processing system **216** may be used to distribute information and power.

[0029] This type of network may include, for example, without limitation, a health monitoring system, a flight control system, an in-flight entertainment system, an environmental control system, and/or any other type of system which exchanges information and/or power in aircraft **200.** In yet other advantageous embodiments, aircraft network data processing system **216** may be implemented during maintenance and service **114** in **Figure 1.** During maintenance and service **114,** upgrades to aircraft **200** may be performed to include aircraft network data processing system **216**.

[0030] The different advantageous embodiments recognize and take into account a number of different considerations. For example, the different advantageous embodiments recognize and take into account that wireless networks may be used to distribute information and power within an aircraft. The different advantageous embodiments, however, recognize that this type of system may have a number of different problems. For example, with a wireless network using transmitters and repeaters within a cabin or fuselage, interference may occur. For example, without limitation, people, galley carts, and/or other items may interfere with the propagation of wireless signals within the aircraft.

[0031] The different advantageous embodiments recognize and take into account that increased power may be needed to transmit the signals for information and power when these signals are transmitted within the cabin or other open areas of the fuselage. These types of signals may cause interference with other devices and/or signals.

[0032] Thus, the different advantageous embodiments provide a method and apparatus for distributing signals within an aircraft. In one advantageous embodiment, a stringer in the aircraft has a channel. A waveguide is located within the channel. The waveguide is capable of carrying a number of signals. In other words, the waveguide is configured to carry the number of signals. The number of signals is selected from at least one of an information signal and a power signal in the illustrative examples.

[0033] As used herein, the phrase "at least one of", when used with a list of items, means that different combinations of one or more of the listed items may be used and only one of each item in the list may be needed. For example, "at least one of item A, item B, and item C" may include, for example, without limitation, item A or item A and item B. This example also may include item A, item B, and item C or item B and item C.

[0034] With reference now to **Figure 3,** a diagram of a network environment is depicted in accordance with an advantageous embodiment. In this illustrative example, network environment **300** may include network data processing system **302.** Network data processing system **302** may take the form of aircraft network data processing system **304** located within aircraft **306** in network environment **300.**

[0035] Network data processing system **302** has network **308** to which number of devices **310** is associated. Number of devices **310** may be any device capable of transmitting and/or receiving at least one of information **312** and power **314** using network **308.** A device in number of devices **310** may be associated with network **308** if the device is capable of transmitting and/or receiving at least one of information **312** and power **314** using network **308.**

[0036] Information **312** may contain information such as, for example, data, commands, programs, and/or other suitable information. Power **314** may be used to power number of devices **310.** A number, as used herein, with reference to items, refers to one or more items. For example, number of devices **310** is one or more devices. In these illustrative examples, number of devices **310** may be, for example, without limitation, number of line replaceable units **316,** number of computers **318,** number of sensor units **320,** number of actuators **322,** and/or any other suitable type of device.

[0037] Network **308** is a medium that provides links **324** between number of devices **310.** Links **324** may carry information **312** and/or power **314.** Links **324** may be facilitated by wires, wireless communication links, fiber optic cables, transmission lines, air interfaces, and/or other suitable types of components. Information **312** and power **314** may be transmitted or carried within links **324** as signals **326.**

[0038] In the different illustrative examples, at least a portion of links **324** may be provided using number of stringers **328.** Number of stringers **328** may be located in interior **330** of aircraft **306.** Number of stringers **328** may have number of waveguides **332.**

[0039] In these illustrative examples, number of stringers **328** may take the form of number of composite stringers **333.** In these illustrative examples, number of waveguides **332** and number of stringers **328** may carry signals **326** in the form of number of wireless signals **334.** Number of wireless signals **334** may include at least one of information signal **336** and power signal **338.**

[0040] In these illustrative examples, number of stringers **328** may be connected to structures within aircraft **306** such as, for example, without limitation, fuselage **340,** skin **342,** ribs **344,** frame **346,** and/or other suitable structures within aircraft **306.** Number of stringers **328** may be noncontiguous. In other words, number of stringers **328,** when more than one stringer is present, may not be connected to each other within network **308**.

[0041] As a result, number of stringers **328** may be connected to each other to form network **308**. Further, within network **308,** if more than one stringer is present within number of stringers **328,** these stringers may be connected to each other. For example, without limitation, stringer **348** and stringer **350** in number of stringers **328** may be connected to each other using transmission line **352.** Transmission line **352** may be, for example, without limitation, any structure capable of conducting information signal **336** and/or power signal **338.** For example, without limitation, transmission line **352** may be a coaxial cable, an optical cable, and/or some other suitable type of cable.

[0042] In some illustrative examples, number of antennas **354** may be connected to number of stringers **328** to transmit number of wireless signals **334** into local area **356** in which portion **358** of number of devices **310** may be located. Local area **356** may be any location within aircraft **306.** For example, local area **356** may be in a crown of the cabin, between the skin panel in an interior wall of the cabin in aircraft **306,** and/or some other suitable location.

[0043] In the illustrative examples, composite stringer **360** is an example of a stringer within number of composite stringers **333.** Composite stringer **360** may have channel **362.** Foam **364** may be located within channel **362.** Additionally, foam **364** also may have channel **366.**

[0044] Waveguide **368** is an example of a waveguide within number of waveguides **332** and is located within channel **366.** Waveguide **368** may be comprised of conductive material **370** and/or dielectric material **372.** Depending on the particular implementation, waveguide **368** may be attached to wall **374** of channel **366.** Of course, in other advantageous embodiments, waveguide **368** may take the form of structure **376** located within channel **366.**

[0045] When waveguide **368** takes the form of conductive material **370,** conductive material **370** may be metal **378.** As a specific example, metal **378** may be a coating applied to wall **374,** a foil, a sheet, or some other suitable form of metal **378.** In these illustrative examples, metal **378** may be, for example, without limitation, a copper foil. Metal **378** may be attached to wall **374** through a number of different mechanisms. For example, without limitation, metal **378** may be applied using conductive paint, electrolysis metal vapor deposition, and/or other suitable mechanisms.

[0046] The illustration of network environment **300** in **Figure 3** is not meant to imply physical or architectural limitations to the manner in which different advantageous embodiments may be implemented. Other components in addition to and/or in place of the ones illustrated may be used. Some components may be unnecessary in some advantageous embodiments. Also, the blocks are presented to illustrate some functional components. One or more of these blocks may be combined and/or divided into different blocks when implemented in different advantageous embodiments.

[0047] For example, in some advantageous embodiments, network **308** may contain only number of stringers **328.** Further, some stringers within number of stringers **328** may not include waveguides. As another example, in some advantageous embodiments, only information **312** may be distributed through network **308.** In other advantageous embodiments, a stringer within number of stringers **328** may contain multiple waveguides.

[0048] In the illustrative examples, waveguide **368** is located within channel **362** for composite stringer **360.** In these depicted examples, waveguide **368** is located within channel **366** within foam **364,** which is located within channel **362.** In other advantageous embodiments, waveguide **368** may be located within channel **362** in composite stringer **360** without foam **364.** For example, waveguide **368** may be formed in channel **362** using conductive material **370** and/or dielectric material **372.**

[0049] Turning now to **Figure 4,** a diagram illustrating a portion of a fuselage of an aircraft is depicted in accordance with an advantageous embodiment. In this illustrative example, fuselage **400** is an example of a portion of a fuselage in aircraft **200** in **Figure 2.**

[0050] Fuselage **400** has skin **402,** which may be supported by structures, such as ribs **404.** Stringers **406** may interconnect and/or run through ribs **404** in the direction of arrow **408.** In these illustrative examples, one or more of stringers **406** may have waveguides and carry wireless signals.

[0051] For example, stringers **410, 412,** and **414** are attached to skin **402** and carry wireless signals **416, 418,** and **420.** Additionally, stringers **422** also may extend in the direction of arrow **424** within fuselage **400.** In this illustrative example, stringer **426** carries wireless signal **429.** These different wireless signals may be, for example, information signals and/or power signals.

[0052] Further, access points **428, 430, 432, 434,** and **436** may provide access points to stringers **410, 412, 414,** and **426** to transmit wireless signals **416, 418, 420,** and **429** outside of the waveguides in these stringers. Access point **428** is integrated or located on stringer **410.** Access point **430** is located on stringer **412,** and access point **436** is located on stringer **414.** Access points **432** and **434** are located on stringer **426** in this illustrative example. These components form network **438** in fuselage **400.** Network **438** is an example of a network, such as network **308** in **Figure 3.**

[0053] With reference now to **Figure 5,** a diagram illustrating composite stringers connected to each other in a network is depicted in accordance with an advantageous embodiment. In this illustrative example, network **500** is an example of one implementation of network **308** in **Figure 3.** Network **500** may be comprised of composite stringer **502,** composite stringer **504,** and composite stringer **508.** Composite stringers **502, 504,** and **508** are examples of composite stringers that may be connected to each other within number of stringers **328** in **Figure 3.**

[0054] These composite stringers are connected to each other using transmission lines **510** and **512.** The connection of these composite stringers in network **500** may form a bus. In this illustrative example, composite stringer **502** is connected to composite stringer **504** by transmission line **510.** Composite stringer **504** is connected to composite stringer **508** by transmission line **512.**

[0055] Input **514** provides an input for a signal from a radio frequency generator in these illustrative examples. Wireless signals may be transmitted through the waveguides in composite stringers **502, 504,** and **508** to output **516,** which may be connected to a sensor either by a transmission line or a wireless interface.

[0056] Turning now to **Figure 6,** a diagram illustrating a cross-sectional perspective view of a hat-shaped stringer with a waveguide is depicted in accordance with an advantageous embodiment. Composite stringer **600** is an example of an implementation of composite stringer **360** in **Figure 3.**

[0057] In this illustrative example, composite stringer **600** has a hat-shape. Composite stringer **600** is comprised of composite material **602,** foam **604,** and conductive material **606** for waveguide **608.** In this illustrative example, waveguide **608** is a rectangular waveguide. Of course, other shapes for waveguide **608** may be selected. For example, waveguide **608** may be rectangular, oval, circular, or some other suitable shape.

[0058] With reference next to **Figure 7**, a diagram of a cross-sectional perspective view of a portion of a composite stringer is depicted in accordance with an advantageous embodiment. In this example, composite stringer **700** is an example of another implementation for composite stringer **360** in **Figure 3.**

[0059] In this illustrative example, composite stringer **700** comprises composite material **702,** foam **704,** and conductive material **706,** which forms a structure for waveguide **708.** In this example, conductive material **706** on side **710** of waveguide **708** may be formed against skin panel **712.**

[0060] The examples of composite stringers illustrated in **Figures 6-7** may employ conductive materials in various forms as described above. For example, without limitation, if copper foil was used, an adhesive film or some other form of adhesive may be applied to the copper foil. This adhesive film may be used to adhere the copper foil to the foam during the curing process.

[0061] Further, the illustrative examples show that the waveguides do not need to be completely encompassed within the foam. For example, in **Figure 7,** portions of the waveguide may be located against a composite material for the stringer or against skin panel **712**. Also, although only a single waveguide is illustrated in these examples, other advantageous embodiments may employ more than one waveguide that extends through the stringer.

[0062] Turning now to **Figure 8,** a diagram illustrating a cross-sectional view of a waveguide with an access point is depicted in accordance with an advantageous embodiment. Composite stringer **800** may be used to implement composite stringers such as, for example, composite stringers **502, 504,** and **508** in **Figure 5.** In this illustrative example, composite stringer **800** comprises composite material **802,** foam **804,** and conductive material **806** for waveguide **808.**

[0063] Conductive material **806** may be placed against wall **810** of foam **804** and skin panel **812.** Access point **814** may be created using coaxial cable **816.** Coaxial cable **816** may have center conductor **818** extend into cavity **820** of waveguide **808.** Center conductor **818** allows for a propagation of waves within cavity **820** to travel through coaxial cable **816.** Coaxial cable **816** may terminate in component **821.** Coaxial cable **816,** with center conductor **818,** is an example a transmission line used as a probe in cavity **820**. Component **821** may be another device, antenna, stringer, or some other suitable component. In other advantageous embodiments, an antenna may be integrated and/or placed into cavity **820** to form access point **814.**

[0064] Distance **822** may be a distance that center conductor **818** extends into cavity **820.** Distance **824** may be a distance from wall **826** to center conductor **818.** These distances may be determined, in the illustrative examples, using a computer program to optimize the electrical performance of the coax-waveguide interface for the desired frequency range and selected waveguide size.

[0065] With reference now to **Figure 9,** a diagram of a composite stringer with a location for an access point is depicted in accordance with an advantageous embodiment. In this illustrative example, composite stringer **900** is an example of an implementation of composite stringer **360** in **Figure 3.**

[0066] Composite stringer **900** may be comprised of composite material **902,** foam **904,** and conductive material **906.** Conductive material **906** is located in channel **908** of foam **904** and forms waveguide **910** within composite stringer **900.** In this illustrative example, plated hole **912** may be located at distance **914** from end **916** of composite stringer **900.** Distance **914** may be determined by using a computer program to optimize the electrical performance of the coax-waveguide interface for the desired frequency range and selected waveguide size. The probe of **Figure 8** may be inserted in plated hole **912**.

[0067] Turning now to **Figure 10**, a diagram of a data processing system is depicted in accordance with an advantageous embodiment. Data processing system **1000** is an example of a device that may be present in number of devices **310** in **Figure 3.** In particular, data processing system **1000** may be used to implement devices such as, for example, without limitation, number of line replaceable units **316** and number of computers **318** in **Figure 3.**

[0068] Data processing system **1000** may receive information from number of sensor units **320** and/or other devices within number of devices **310** in **Figure 3.** In this illustrative example, data processing system **1000** includes communications fabric **1002**, which provides communications between processor unit **1004**, memory **1006**, persistent storage **1008**, communications unit **1010**, input/output (I/O) unit **1012**, and display **1014**.

[0069] Processor unit **1004** executes instructions for software that may be loaded into memory **1006**. Processor unit **1004** may be a set of one or more processors or may be a multi-processor core, depending on the particular implementation. Further, processor unit **1004** may be implemented using one or more heterogeneous processor systems in which a main processor is present with secondary processors on a single chip. As another illustrative example, processor unit **1004** may be a symmetric multi-processor system containing multiple processors of the same type.

[0070] Memory **1006** and persistent storage **1008** are examples of storage devices **1016**. A storage device is any piece of hardware that is capable of storing information, such as, for example without limitation, data, program code in functional form, and/or other suitable information either on a temporary basis and/or a permanent basis.

[0071] Memory **1006**, in these examples, may be, for example, a random access memory or any other suitable volatile or non-volatile storage device. Persistent storage **1008** may take various forms, depending on the particular implementation. For example, persistent storage **1008** may contain one or more components or devices. For example, persistent storage **1008** may be a hard drive, a flash memory, a rewritable optical disk, a rewritable magnetic tape, or some combination of the above.

[0072] Communications unit **1010,** in these examples, provides for communications with other data processing systems or devices. In these examples, communications unit **1010** is a network interface card.

[0073] Input/output unit **1012** allows for input and output of data with other devices that may be connected to data processing system **1000**. For example, input/output unit **1012** may provide a connection for user input through a keyboard, a mouse, and/or some other suitable input device. Further, input/output unit

1012 may send output to a printer. Display **1014** provides a mechanism to display information to a user.

[0074] Instructions for the operating system, applications, and/or programs may be located in storage devices **1016,** which are in communication with processor unit **1004** through communications fabric **1002.** In these illustrative examples, the instructions are in a functional form on persistent storage **1008**. These instructions may be loaded into memory **1006** for execution by processor unit **1004**. The processes may be performed by processor unit **1004** using computer-implemented instructions, which may be located in a memory, such as memory **1006**.

[0075] These instructions are referred to as program code, computer usable program code, or computer readable program code that may be read and executed by a processor in processor unit **1004**. The program code in the different embodiments may be embodied on different physical or tangible computer readable media, such as memory **1006** or persistent storage **1008**.

[0076] The illustrations of data processing system **1000** in **Figure 10** is not meant to imply physical or architectural limitations to the manner in which different devices may be implemented. Other sensor units and data processing systems may include other components in addition to or in place of the ones illustrated. Further, some advantageous embodiments may exclude some of the components illustrated. For example, in some advantageous embodiments, display **1014** in data processing system **1000** may be unnecessary. .

[0077] With reference now to **Figure 11,** a flowchart of a process for transmitting wireless signals in a vehicle is depicted in accordance with an advantageous embodiment. The process illustrated in **Figure 11** may be implemented in a network environment, such as network environment **300** in **Figure 3.** More specifically, the process illustrated in this figure may be implemented in network data processing system **302** in **Figure 3** in a vehicle. This vehicle may take various forms, such as aircraft **306** in **Figure 3.**

[0078] The process begins by transmitting a number of wireless signals from a first device into a number of waveguides located in a number of stringers in a vehicle (operation **1100**). These wireless signals may be transmitted into a waveguide in the number of waveguides in operation **1100** by the first device. This transmission may be made through a cable or other connector connecting the first device to the waveguide.

[0079] Alternatively, the first device may transmit the number of wireless signals through an air interface, which is received at an antenna connected to the waveguide. In this manner, the first device is associated with this waveguide. The association, as illustrated in this example, may be a physical connection or a wireless connection that allows for transmission of the wireless signals from the first device into the waveguide in the number of waveguides. In this manner, these wireless signals may be transmitted into the waveguide.

[0080] The process then carries the number of wireless signals in the number of waveguides in the number of stringers (operation **1102**). The number of wireless signals is received from the number of waveguides at a second device (operation **1104**), with the process terminating thereafter. In this illustrative example, the number of wireless signals may be sent to the second device, which is associated with the number of waveguides.

[0081] The second device is associated with the number of waveguides by being able to receive the wireless signals from one or more of the number of waveguides. As with the first device, the second device may be connected to one or more of the waveguides at an access point. In other advantageous embodiments, the access point may have an antenna that radiates the wireless signals into an air interface that may be received by the second device.

[0082] The flowcharts and block diagrams in the different depicted embodiments illustrate the architecture, functionality, and operation of some possible implementations of apparatus and methods in different advantageous embodiments. In this regard, each block in the flowchart or block diagrams may represent a module, segment, function, and/or a portion of an operation or step. In some alternative implementations, the function or functions noted in the block may occur out of the order noted in the figures. For example, in some cases, two blocks shown in succession may be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved.

[0083] Thus, the different advantageous embodiments provide a method and apparatus for transmitting wireless signals. In one advantageous embodiment, an apparatus comprises a stringer having a channel. A waveguide is located within the channel in which the waveguide is capable of carrying a number of wireless signals.

[0084] In the different advantageous embodiments, the stringer may take the form of a composite stringer having a foam core in which the waveguide is located within a channel in the foam core. These stringers may be located in the interior of an aircraft. The stringers may be located along the skin panels of the aircraft or extend across the fuselage of the aircraft.

[0085] By incorporating waveguides into these stringers, the different advantageous embodiments provide a capability to transmit information and/or power through these waveguides to different devices. With the use of these stringers, additional weight, complexity, and/or expense may be decreased. These waveguides may be built into the aircraft during the manufacturing of the aircraft. In some advantageous embodiments, these types of stringers may be added to the aircraft during maintenance as an upgrade or refurbishment of aircraft.

[0086] Further, the use of stringers containing waveguides also reduces the amount of power needed to transmit wireless signals. The design of the waveguides may be such to allow for low power usage as compared to currently available wireless systems. Also, with one or more of the different advantageous embodiments, the interference and/or reduction of power signals may be avoided as compared to the transmission of wireless signals through the cabin of an aircraft in which obstructions, such as people or carts, may be present.

[0087] The description of the different advantageous embodiments has been presented for purposes of illustration and description, and it is not intended to be exhaustive or limited to the embodiments in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art.

[0088] Although the different advantageous embodiments have been described with respect to aircraft, the different advantageous embodiments also may be applied to other types of structures. For example, without limitation, the different advantageous embodiments may be applied to vehicles, such as a spacecraft, a submarine, a surface ship, and/or some other suitable type of vehicle. The different advantageous embodiments may even be applied to structures that are stationary or non-mobile in addition to vehicles.

[0089] Further, different advantageous embodiments may provide different advantages as compared to other advantageous embodiments. The embodiment or embodiments selected are chosen and described in order to best explain the principles of the embodiments, the practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

CLAIMS:

What is claimed is:

1. An apparatus comprising:

a stringer having a channel; and

a waveguide located within the channel, wherein the waveguide is capable of carrying a number of wireless signals.

2. The apparatus of claim 1 further comprising:

a plurality of devices associated with the stringer, wherein the plurality of devices is capable of exchanging the number of wireless signals carried in the waveguide.

3. The apparatus of claim 1, wherein the stringer is capable of being attached to one of a skin on a fuselage of an aircraft, a skin on a wing of the aircraft, a frame of the aircraft, and a rib of the aircraft.

4. The apparatus of claim 2, wherein the plurality of devices and the stringer are part of a network data processing system.

5. The apparatus of claim 4, wherein the network data processing system is located in a vehicle.

6. The apparatus of claim 4, wherein the network data processing system is selected from at least one of a health monitoring system, a flight control system, an in-flight entertainment system, and an environmental control system.

7. The apparatus of claim 1 further comprising:

a number of stringers, wherein each of the number of stringers has an associated waveguide.

8. The apparatus of claim 1 further comprising:
an access point to the waveguide.

9. The apparatus of claim 8, wherein the access point comprises one of a transmission line, a probe, and an antenna.

10. The apparatus of claim 1, wherein the stringer comprises:
a composite part having a first channel; and
foam located within the first channel, wherein the foam has a second channel, wherein the waveguide is located within the second channel.

11. The apparatus of claim 10, wherein the waveguide comprises a metal material attached to a wall of the second channel.

12. The apparatus of claim 1 further comprising:
an aircraft, wherein the stringer is attached to an interior of the aircraft.

13. The apparatus of claim 1, wherein the stringer comprises:
a composite stringer having the channel; and
a conductive material in the channel, wherein the conductive material forms the waveguide.

14. A method for transmitting wireless signals in a vehicle, the method comprising:
transmitting a number of wireless signals from a first device into a number of waveguides located in a number of stringers in the vehicle;
carrying the number of wireless signals in the number of waveguides in the number of stringers; and

receiving the number of wireless signals from the number of waveguides at a second device.

15. The method of claim 14, wherein the number of waveguides in the number of stringers are part of a network in the vehicle, and wherein the network further comprises at least one of a number of transmission lines, a number of optical cables, and a number of air interfaces.

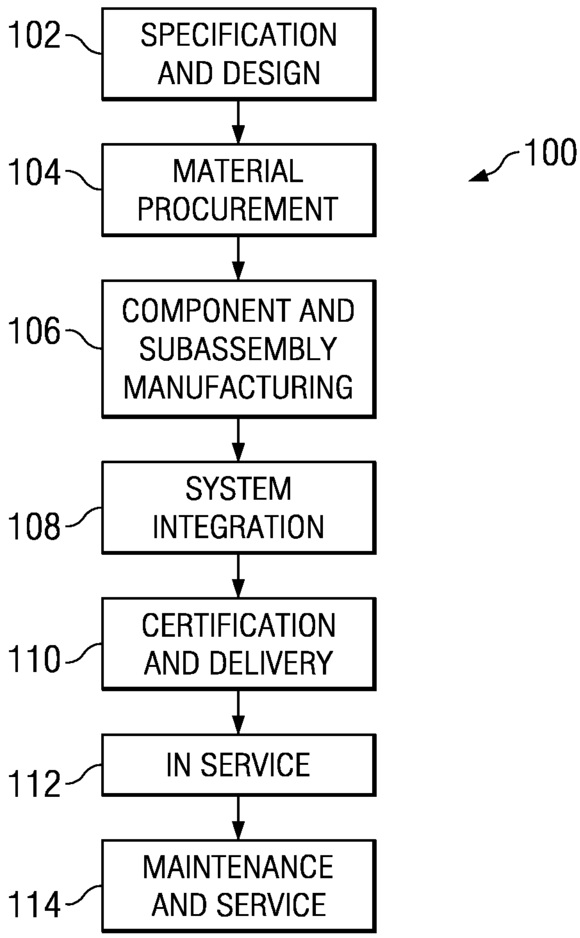

102
SPECIFICATION AND DESIGN
104
MATERIAL PROCUREMENT
106
COMPONENT AND SUBASSEMBLY MANUFACTURING
108
SYSTEM INTEGRATION
110
CERTIFICATION AND DELIVERY
112
IN SERVICE
114
MAINTENANCE AND SERVICE
100

FIG. 1

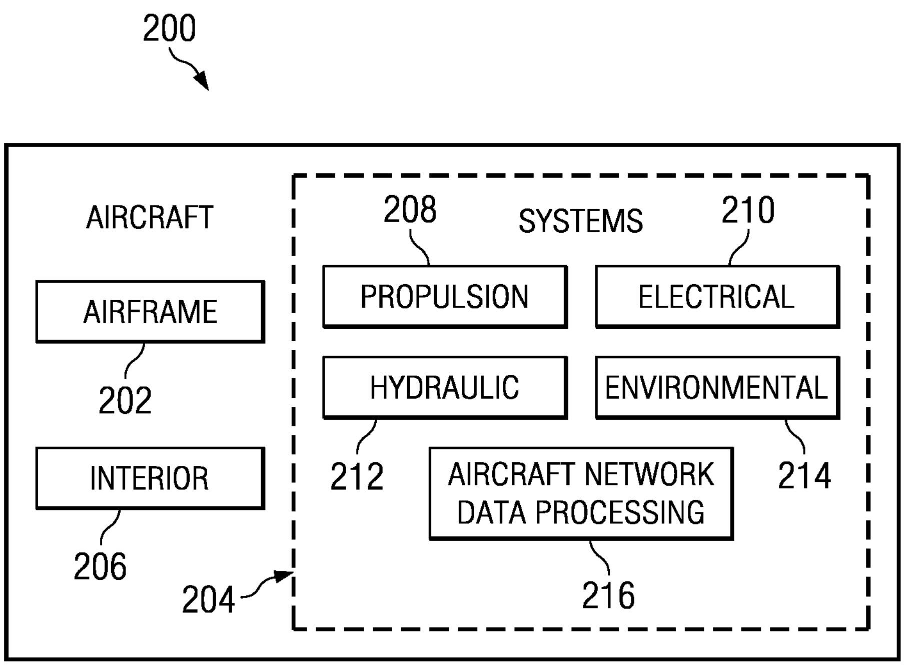
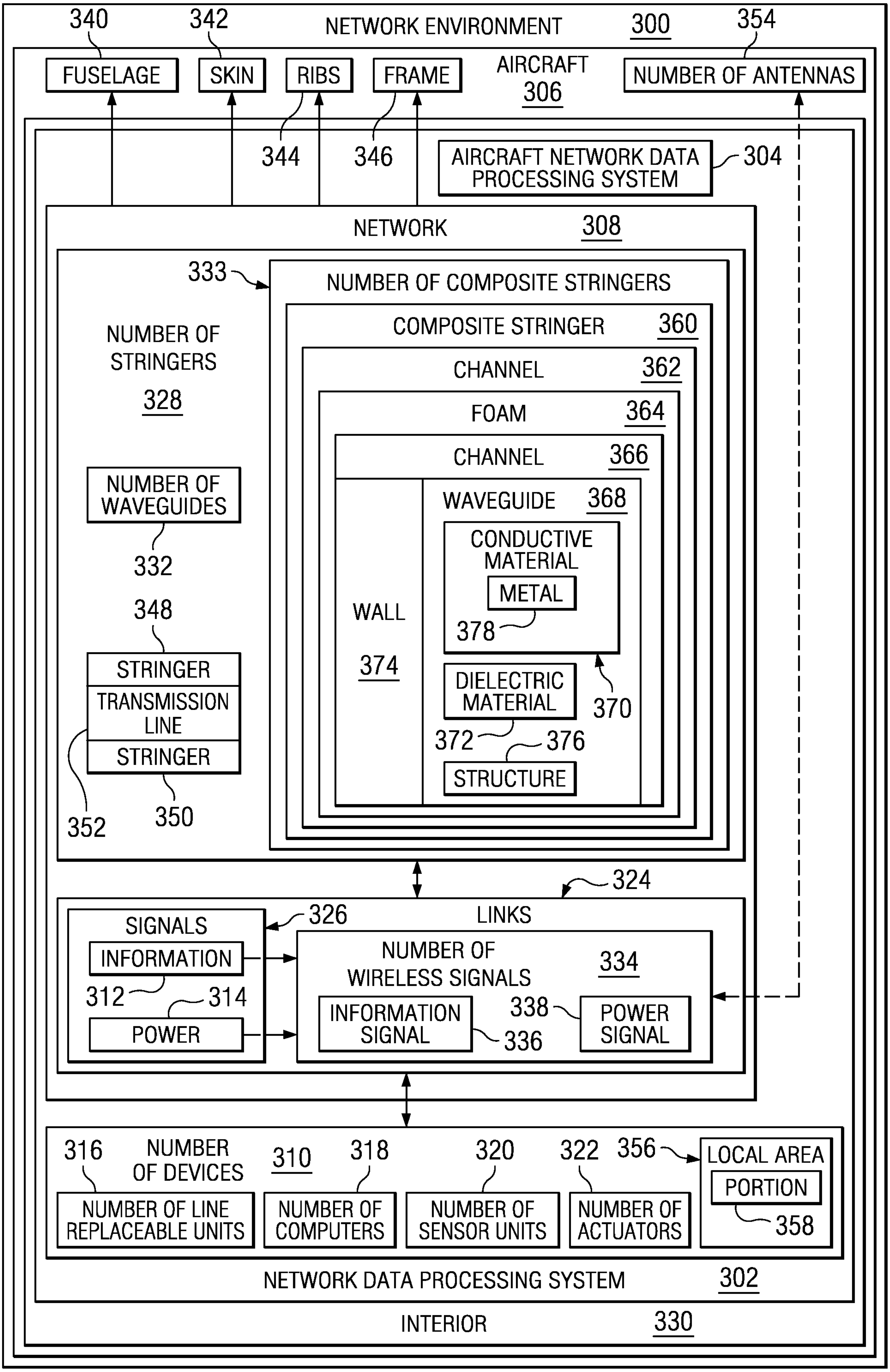

200
AIRCRAFT
AIRFRAME
202
INTERIOR
206
204
SYSTEMS
208
PROPULSION
210
ELECTRICAL
HYDRAULIC
ENVIRONMENTAL
212
214
AIRCRAFT NETWORK DATA PROCESSING
216

FIG. 2

FIG. 3



NETWORK ENVIRONMENT 300
AIRCRAFT 306
FUSELAGE 340
SKIN 342
RIBS 344
FRAME 346
NUMBER OF ANTENNAS 354
AIRCRAFT NETWORK DATA PROCESSING SYSTEM 304
NETWORK 308
NUMBER OF STRINGERS 328
333
NUMBER OF COMPOSITE STRINGERS
COMPOSITE STRINGER 360
CHANNEL 362
FOAM 364
CHANNEL 366
WAVEGUIDE 368
CONDUCTIVE MATERIAL
METAL
378
370
DIELECTRIC MATERIAL
372
376
STRUCTURE
WALL 374
NUMBER OF WAVEGUIDES 332
348
STRINGER
TRANSMISSION LINE
STRINGER
352
350
324
LINKS
SIGNALS
326
INFORMATION
312
314
POWER
NUMBER OF WIRELESS SIGNALS 334
INFORMATION SIGNAL
336
338
POWER SIGNAL
316
NUMBER OF DEVICES 310
318
320
322
356
NUMBER OF LINE REPLACEABLE UNITS
NUMBER OF COMPUTERS
NUMBER OF SENSOR UNITS
NUMBER OF ACTUATORS
LOCAL AREA
PORTION
358
NETWORK DATA PROCESSING SYSTEM 302
INTERIOR 330

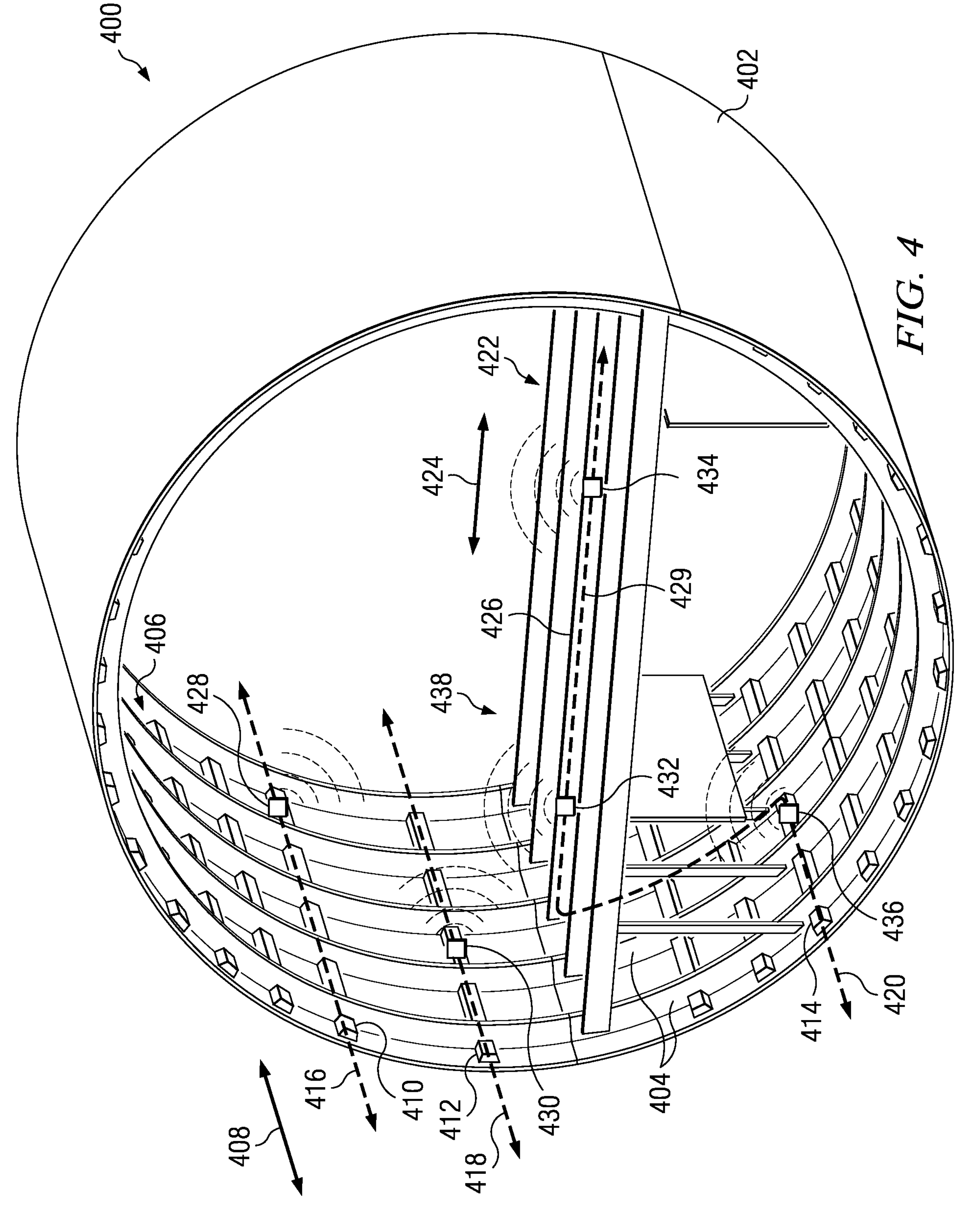

400
402
404
406
408
410
412
414
416
418
420
422
424
426
428
429
430
432
434
436
438

FIG. 4

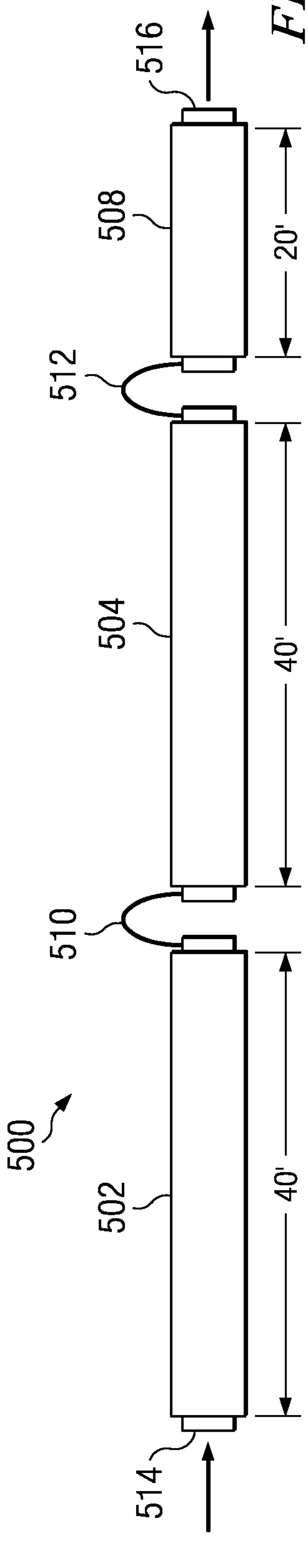


FIG. 5

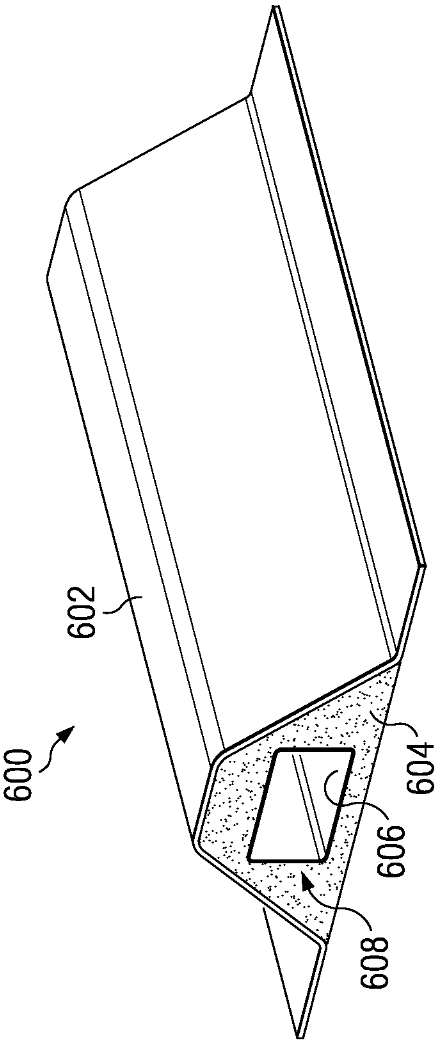


FIG. 6

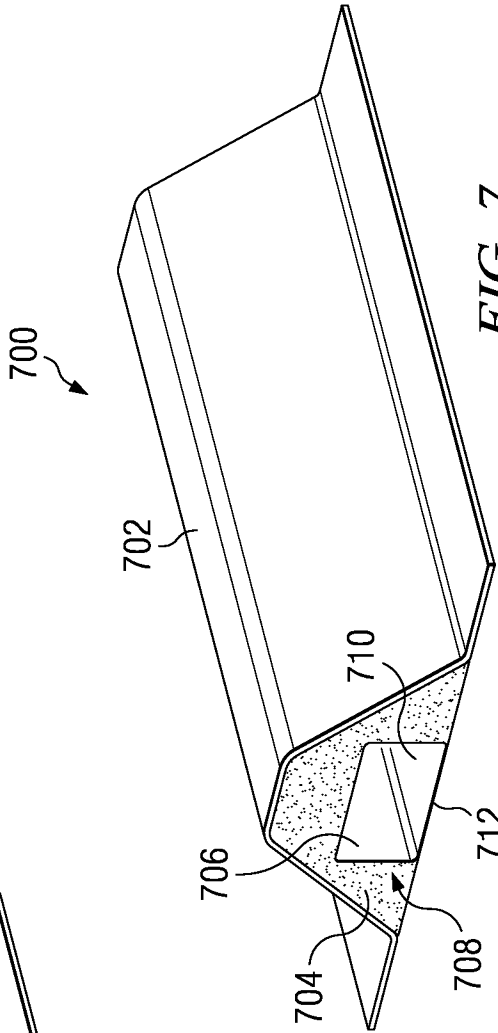


FIG. 7

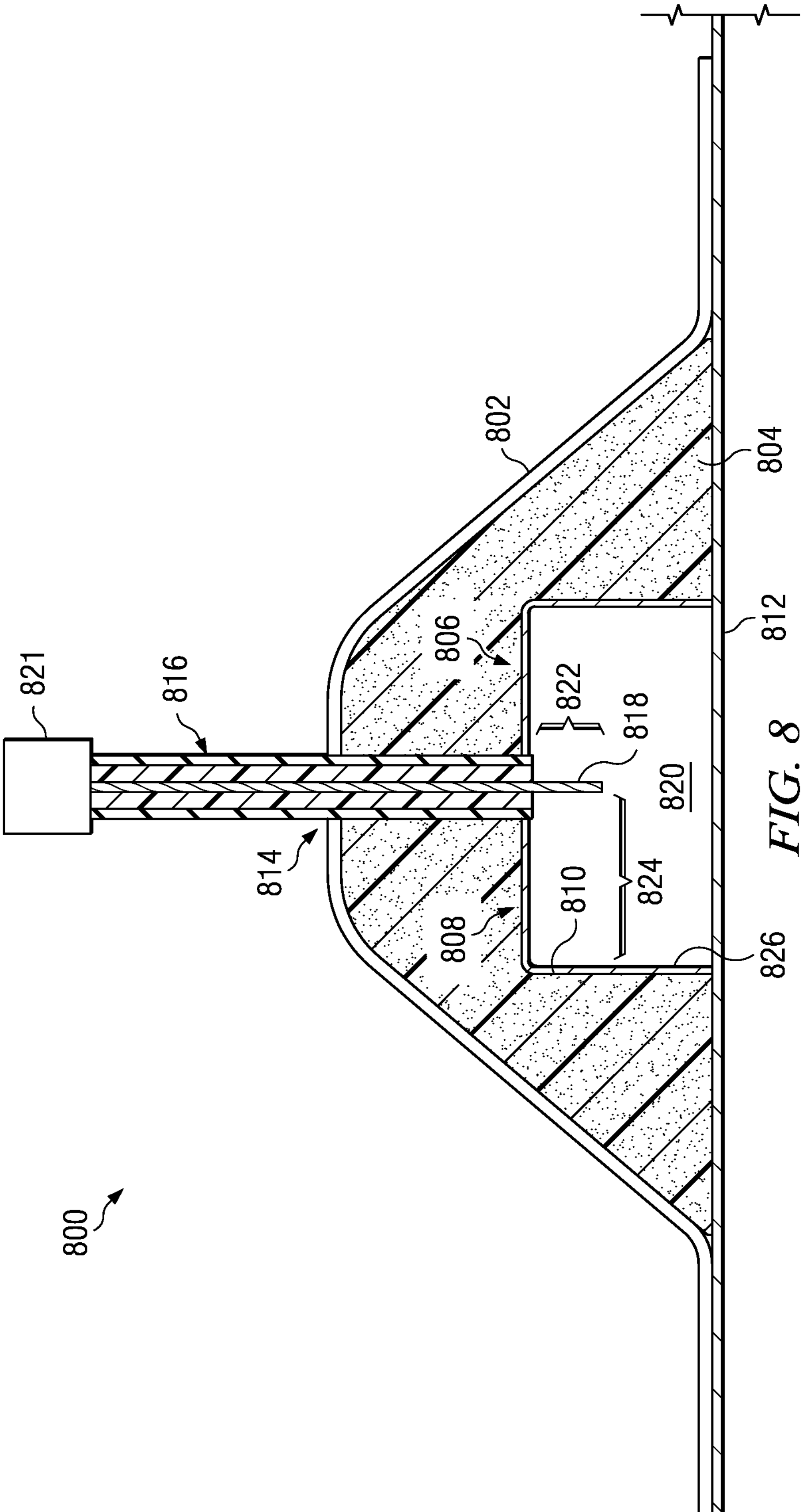


FIG. 8

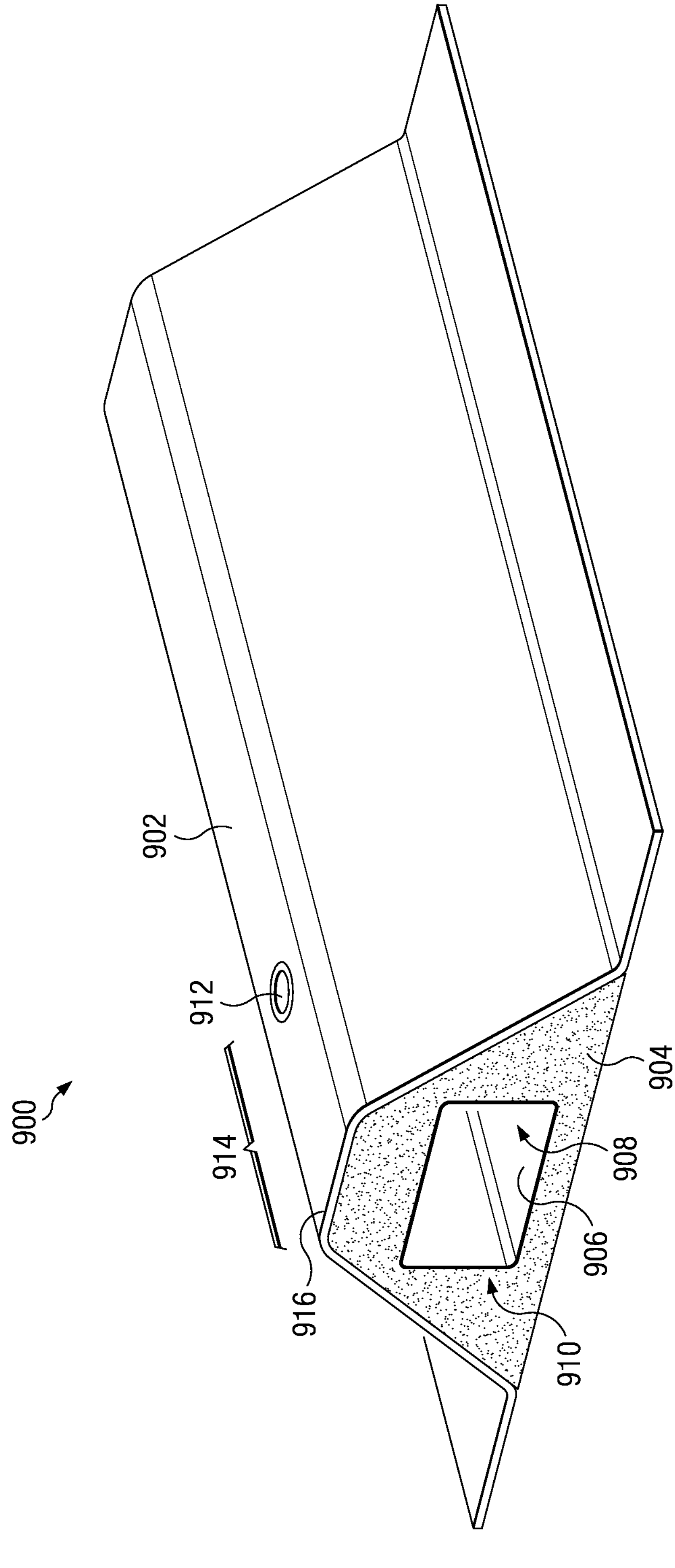


FIG. 9

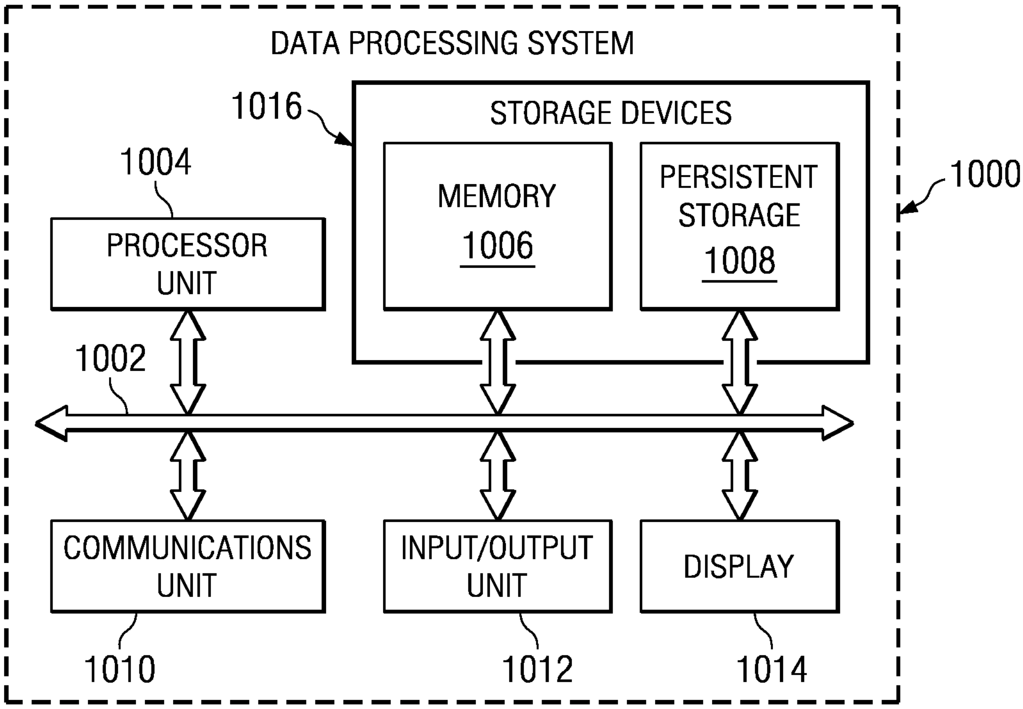

DATA PROCESSING SYSTEM
1016
STORAGE DEVICES
1004
MEMORY
1006
PERSISTENT
STORAGE
1008
1000
PROCESSOR
UNIT
1002
COMMUNICATIONS
UNIT
INPUT/OUTPUT
UNIT
DISPLAY
1010
1012
1014

FIG. 10

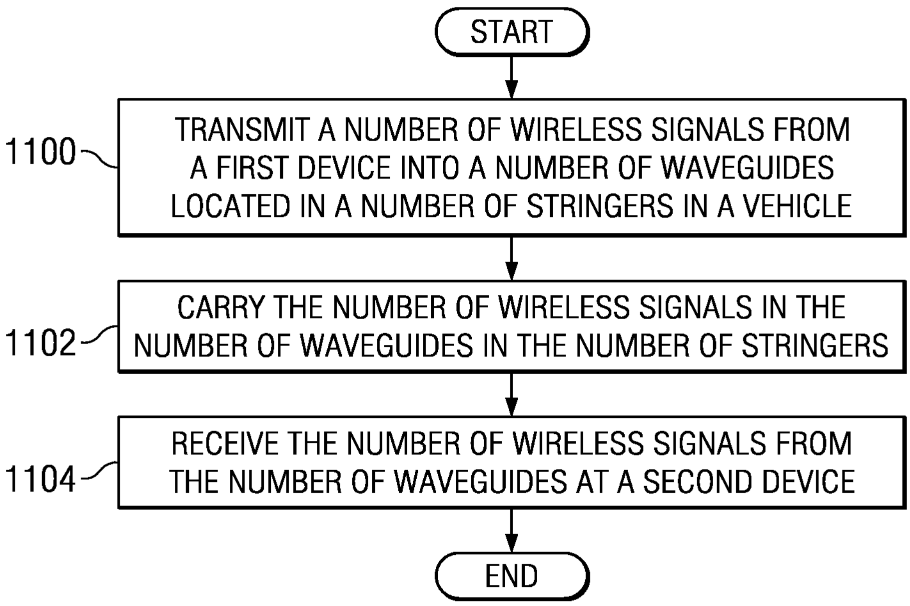

START
1100
TRANSMIT A NUMBER OF WIRELESS SIGNALS FROM A FIRST DEVICE INTO A NUMBER OF WAVEGUIDES LOCATED IN A NUMBER OF STRINGERS IN A VEHICLE
1102
CARRY THE NUMBER OF WIRELESS SIGNALS IN THE NUMBER OF WAVEGUIDES IN THE NUMBER OF STRINGERS
1104
RECEIVE THE NUMBER OF WIRELESS SIGNALS FROM THE NUMBER OF WAVEGUIDES AT A SECOND DEVICE
END

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/036082

A. CLASSIFICATION OF SUBJECT MATTER
INV. B64D45/00
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)
B64D H01P

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 86/01039 A1 (COMMW OF AUSTRALIA [AU]) 13 February 1986 (1986-02-13) page 1, line 21 - line 25	1 2-15
Y	US 2008/185478 A1 (DANNENBERG HEIKO [DE]) 7 August 2008 (2008-08-07) * abstract figure 1 paragraph [0014] - paragraph [0016] paragraph [0025] - paragraph [0026] paragraph [0047]	3,7,12, 14
Y	US 5 363 464 A (WAY JAMES A [US] ET AL) 8 November 1994 (1994-11-08) * abstract figures 2C, 2D column 4, line 46 - line 63	10,11,13

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 November 2010	18/11/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Estrela Calpe, Jordi

International application No
PCT/US2010/036082

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2008/010841 A1 (VOGLEY WILBUR C [US]; STONER PAUL [US]) 24 January 2008 (2008-01-24) * abstract; figure 1	2,4-6,8, 9,15
A	US 5 222 166 A (WELTHA M DUANE [US]) 22 June 1993 (1993-06-22) * abstract figure 1	1-15
A	"How about this? Avionics would go in plane's skin", ELECTRONICS, VNU BUSINESS PUBLICATIONS, NEW YORK, US, vol. 60, no. 21, 15 October 1987 (1987-10-15), page 39,42, XP002210354, ISSN: 0883-4989 the whole document	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2010/036082

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
WO 8601039	A1	13-02-1986	EP	0191790	A1	27-08-1986
US 2008185478	A1	07-08-2008	DE	102006050534	A1	30-04-2008
US 5363464	A	08-11-1994	AU	7115994	A	17-01-1995
			WO	9500979	A2	05-01-1995
WO 2008010841	A1	24-01-2008	US	2008019698	A1	24-01-2008
US 5222166	A	22-06-1993	NONE			