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### Patent support with energy transfer

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#### Abstract

A patient support system includes a patient support apparatus and a powered device mounted relative to the patient support apparatus and an electrical circuit to power the powered device, with the electrical circuit having a wireless power receiver to inductively couple to and transfer electrical energy from a wireless power transmitter when the wireless power receiver is in proximity to the wireless power transmitter.

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## Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application claims priority as a continuation application of U.S. patent application Ser. No. 16/752,094, filed Jan. 24, 2020, now U.S. Pat. No. 11,793,699, entitled PATIENT SUPPORT WITH ENERGY TRANSFER, by Applicant Stryker Corporation, which is a continuation application U.S. patent application Ser. No. 15/040,593, filed Feb. 10, 2016, now U.S. Pat. No. 10,561,551, entitled PATIENT SUPPORT WITH ENERGY TRANSFER, by Applicant Stryker Corporation, which is a continuation application U.S. patent application Ser. No. 14/517,973, filed Oct. 20, 2014, now U.S. Pat. No. 9,289,336, entitled PATIENT SUPPORT WITH ENERGY TRANSFER, by Applicants Stryker Corporation, which is a continuation application of U.S. patent application Ser. No. 13/296,656,

filed Nov. 15, 2011, now U.S. Pat. No. 8,864,205, and entitled PATIENT SUPPORT WITH WIRELESS DATA AND/OR ENERGY TRANSFER, by Applicants Guy Lemire, et al., which is a continuation-in-part application to U.S. patent application Ser. No. 11/769,959, filed Jun. 28, 2007, now U.S. Pat. No. 8,056,163, and entitled PATIENT SUPPORT, filed by inventors Guy Lemire, et al., which in turn claims priority to U.S. provisional application Ser. Nos. 60/817,528, filed Jun. 28, 2006, and 60/830,397, filed Jul. 11, 2006. U.S. patent application Ser. No. 13/296,656 also claims priority as a continuation-in-part application to U.S. patent application Ser. No. 12/886,987, filed Sep. 21, 2010, now U.S. Pat. No. 8,439,416 and entitled AMBULANCE COT AND LOADING AND UNLOADING SYSTEM, by applicants Clifford Lambarth et al., which claims priority to U.S. provisional applications 61/248,374, filed Oct. 2, 2009, and 61/248,654, filed Oct. 5, 2009, and which claims priority as a continuation-in-part application to U.S. patent application Ser. No. 12/145,037, filed Jun. 24, 2008, now U.S. Pat. No. 7,887,113, entitled POWERED PATIENT SUPPORT AND FASTENING SYSTEM WITH INDUCTIVE BASED POWER SYSTEM, which in turn claims priority to U.S. provisional application Ser. No. 60/949,005, filed Jul. 11, 2007. The disclosures of all of the aforementioned patents and patent applications are hereby incorporated herein in their entireties by reference.

## BACKGROUND OF THE INVENTION

(1) The present invention relates to patient support apparatuses—such as cots, stretchers, beds, surgical tables, wheelchairs, chairs, and the like—and more particularly to wireless methods and structures for transferring data and/or power to or from such devices, or components of such devices.

(2) Patient support apparatuses are commonly used in healthcare environments for supporting patients. Such support apparatuses often include electrical components, such as, but not limited to, motors, actuators, lights, control panels, sensors, and still other devices. Such devices may receive their electrical power from one or more batteries provided on the patient support apparatus, or from a wired connection to a conventional electrical wall outlet.

## SUMMARY OF THE INVENTION

(3) The present invention provides improved methods and structures for delivering electrical power to a patient support apparatus, and/or delivering electrical power to a component of the patient support apparatus. In other embodiments, the present invention also provides improved methods and structures for communicating electronic signals between components of the patient support apparatus. In various of the embodiments, the present invention reduces the weight and bulk of various components of the patient support apparatus, improves the ease in which the support apparatus may be cleaned, and helps to reduce the work involved in connecting the support apparatus, or a component of the support apparatus, to a source of power.

(4) According to one embodiment, a patient support is provided that includes a base, a frame, an elevation adjustment mechanism, a deck, a plurality of electronic control circuits, a wired communication network, and a wireless link. The elevation adjustment mechanism raises and lowers the frame with respect to the base. The deck is supported on the frame and includes a plurality of sections adapted to support a patient thereon. The plurality of electronic control circuits are each adapted to control at least one specific function of the patient support apparatus, and each of the electronic control circuits located in different locations of the patient support apparatus. The wired communication network transports messages between a first subset of the electronic control circuits. The wireless link transports messages between a second subset of the electronic control circuits, wherein the second subset of electronic control circuits includes at least one electronic control circuit that is not in common with the first subset of electronic control circuits.

(5) According to another aspect, a patient support apparatus is provided that includes a base, a frame, an elevation adjustment mechanism, a deck, an electrical power supply, an inductive coil, and a controller. The elevation adjustment mechanism raises and lowers the frame with respect to



the base. The deck is supported on the frame and includes a plurality of sections adapted to support a patient thereon. The electrical power supply supplies electrical power to at least one motor positioned on the patient support apparatus. The inductive coil is positioned on the patient support apparatus and is adapted to receive electrical power from the electrical power supply. The controller controls electrical current that flows through the inductive coil so as to inductively transfer electrical power from the inductive coil to a mattress positioned on the deck.

(6) According to yet another aspect, a patient support apparatus is provided that includes a base, a patient support surface, a rechargeable battery, an on-board inductive coil, and a controller. The base includes a plurality of wheels. The patient support surface provides a surface on which a patient may be supported. The rechargeable battery provides electrical power to at least one electronic device positioned on the patient support apparatus. The on-board inductive coil receives electrical power from an off-board inductive coil when the on-board and off-board inductive coils are positioned within inductive proximity to each other. The controller controls the receipt of electrical power via the on-board inductive coil and supplies the electrical power to the battery for recharging the rechargeable battery.

(7) According to other aspects, the first subset of electronic control circuits may include a first electronic control circuit adapted to control the raising and lowering of the frame with respect to the base, along with a second electronic control circuit adapted to control a user interface on the patient support apparatus. The second subset of electronic control circuits may include a third electronic control circuit adapted to control the inflation of a mattress positioned on the deck.

(8) The wired communication network may be a controller area network (CAN), a LONWorks network, a LIN network, an RS-232 network, a Firewire network, a DeviceNet network, or any other type of network or fieldbus that provides a communication system for communication between electronic control circuits. Regardless of the specific type of network, the wireless link may be between a node on the network and an electronic control circuit adapted to control the inflation of a mattress positioned on the deck, wherein the electronic control circuit that is adapted to control the inflation of a mattress positioned on the deck is an electronic control circuit that is not part of the network.

(9) A battery may be positioned inside of the mattress to supply electrical power to a blower positioned inside of the mattress.

(10) First and second housings for the first and second inductive coils, respectively, may also be provided, and the housings may be configured to selectively engage together in a manner that orients the first and second inductive coils in a desired relative orientation to each other for inductive energy transfer therebetween. The first housing may be mounted to a foot section of the deck.

(11) An indicator may be provided on the patient support apparatus that provides a human-perceptible signal to a caregiver when the first and second housings are engaged. The indicator may include a light and/or the indicator may emit an aural signal. The light may be a separate stand-alone light, or it may be an icon, graphic, or other portion of a display screen.

(12) The patient support apparatus may further include an electronic control circuit that controls the first inductive coil and that includes circuitry adapted to detect when the first and second housings are engaged with each other. One of the first and second housings may include an elongated projection having a sloped wall, and the other one of the first and second housings may include an elongated recess adapted to receive the elongated projection.

(13) The patient support apparatus may further include an inductive coil positioned on an underside of the patient support apparatus that is adapted to inductively couple with a stationary inductive coil positioned on or in a floor.

(14) A controller may automatically determine when a mattress inductive coil is positioned on the support deck and in alignment with the inductive coil. The inductive coil may be positioned at a foot end of the patient support apparatus. A wireless transceiver may be coupled to the patient

support apparatus that wirelessly communicates with a mattress controller contained within the mattress. A control panel may be positioned on the patient support apparatus and include at least one control for controlling a feature of the mattress. The control panel communicates with the wireless transceiver such that a signal relating to the control of the feature may be transmitted from the wireless transceiver to the mattress controller.

(15) A controller may be included that initiates a message to an off-board controller of the off-board inductive coil when the rechargeable battery is charged. The message may cause the off-board controller to terminate the inductive transfer of electrical energy from the off-board inductive coil to the on-board inductive coil.

(16) A brake may be provided on the patient support apparatus and the controller may only allow electrical power to inductively recharge the rechargeable battery when the brake is activated. The patient support apparatus may be one of a chair, a bed, a stretcher, a cot, or a surgical table. The patient support apparatus may further include an electrically powered wheel adapted to assist caregivers in moving the patient support apparatus from one location to another.

(17) An actuator may be included that moves the on-board coil between an extended and a retracted position. The actuator may be configured to automatically move the on-board coil to the extended position when a brake on the patient support apparatus is activated.

(18) According to still other aspects, the patient support apparatus may include one or more on-board coils that inductively receive electrical energy from one or more off-board electrical coils that occupy a greater area than the on-board coil or coils. The greater area of the off-board coil or coils may allow efficient inductive coupling to occur between the off-board and on-board coils in a variety of different positions and a variety of different orientations, thereby avoiding the need for a specific position and/or orientation to be achieved between the two coils before efficient inductive coupling can occur.

(19) Before the embodiments of the invention are explained in detail, it is to be understood that the invention is not limited to the details of operation or to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention may be implemented in various other embodiments and of being practiced or being carried out in alternative ways not expressly disclosed herein. Also, it is to be understood that the phraseology and terminology used herein are for the purpose of description and should not be regarded as limiting. The use of “including” and “comprising” and variations thereof is meant to encompass the items listed thereafter and equivalents thereof as well as additional items and equivalents thereof. Further, enumeration may be used in the description of various embodiments. Unless otherwise expressly stated, the use of enumeration should not be construed as limiting the invention to any specific order or number of components. Nor should the use of enumeration be construed as excluding from the scope of the invention any additional steps or components that might be combined with or into the enumerated steps or components.

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. 1 is a diagram of an illustrative patient support apparatus that may incorporate one or more aspects of the present invention;

(2) FIG. 2 is perspective view of another patient support apparatus that may incorporate one or more aspects of the present invention;

(3) FIG. 3 is a side, elevational view of the patient support apparatus of FIG. 2;

(4) FIG. 4A is a perspective view of rear portion of a patient support apparatus showing an inductive power supply decoupled from a control box of a mattress;

(5) FIG. 4B is a perspective view of the rear portion of the patient support apparatus of FIG. 4A

showing the control box of the mattress coupled to the inductive power supply of the patient support apparatus;

(6) FIG. 5 is perspective view of an illustrative inductive housing receptacle;

(7) FIG. 6 is a perspective view of an illustrative inductive housing projection that is adapted to selectively engage with the inductive housing receptacle of FIG. 5;

(8) FIG. 7 is cross-sectional view of the inductive housing receptacle and inductive housing projection of FIGS. 5 and 6 shown separated from each other;

(9) FIG. 8 is a cross-sectional view of the inductive housing receptacle and inductive housing projection of FIGS. 5 and 6 shown engaging each other and taken along the same cross-sectional plane as that of FIG. 11;

(10) FIG. 9 is a cross-sectional view of the inductive housing receptacle and inductive housing projection of FIGS. 5 and 6 shown separated from each other and taken along a vertical plane that is perpendicular to the cross-sectional plane of FIGS. 7 and 8;

(11) FIG. 10 is a cross-sectional view of the inductive housing receptacle and inductive housing projection of FIGS. 5 and 6 shown engaging each other and taken along the same cross-sectional plane as that of FIG. 9;

(12) FIG. 11 is a block diagram of an electrical communications network that may be present on the patient support apparatuses of FIG. 1 or 2, or any of the other patient support apparatuses described herein;

(13) FIG. 12 is a block diagram of an alternative electrical communications network that may be present on the patient support apparatuses of FIG. 1 or 2, or any of the other patient support apparatuses described herein;

(14) FIG. 13 is a diagram showing the arrangement and relationship between FIGS. 13A, 13B, and 13C, which together illustrate a detailed diagram of one embodiment of the electrical components that may be inside one of the nodes of the electrical communication network, such as, but not limited to, node #4 of FIG. 12;

(15) FIG. 13A is a first portion of the detailed diagram referenced by FIG. 13;

(16) FIG. 13B is a second portion of the detailed diagram referenced by FIG. 13;

(17) FIG. 13C is a third portion of the detailed diagram referenced by FIG. 13;

(18) FIG. 14 is a plan view of an electrical control box that may be incorporated into a mattress supported on the patient support apparatus and that shows the inductive housing receptacle of FIG. 5 affixed thereto;

(19) FIG. 15 is a side, elevational view of the electrical control box of FIG. 14;

(20) FIG. 16 is a partial, sectional view taken along the line XVI-XVI of FIG. 14;

(21) FIG. 17 is a partial, sectional view taken along the line XVII-XVII of FIG. 15;

(22) FIG. 18 is a block diagram of yet another alternative electrical communications network that may be present on the patient support apparatuses of FIG. 1 or 2, or any of the other patient support apparatuses described herein;

(23) FIG. 19 is a perspective view of an inductive power station that may be used to wirelessly provide electrical power to any of the patient support apparatus embodiments described herein, as well as other patient support apparatuses;

(24) FIG. 20 is perspective view of an alternative inductive power station that may be used to wirelessly provide electrical power to any of the patient support apparatus embodiments described herein, as well as other patient support apparatuses;

(25) FIG. 21 is a fragmentary side elevation view of a patient support and emergency vehicle incorporating a loading and unloading device and, further, an induction based power supply system according to one aspect of the present invention;

(26) FIG. 22 is a side elevation view of the patient support and emergency vehicle of FIG. 21 shown with the patient support loaded onto the emergency vehicle;

(27) FIG. 23 is a similar view to FIG. 22 illustrating the loading and unloading device in a stowed

position with the patient support removed for clarity;

(28) FIG. 24 is a similar view to FIG. 21 illustrating another embodiment of a loading and unloading device incorporating aspects of the present invention;

(29) FIG. 25 is a side elevation view of the patient support of FIG. 21 being loaded into a vehicle;

(30) FIG. 26 is a side elevation view of the patient support of FIG. 21 in a fully stowed position within the vehicle;

(31) FIG. 27 is a perspective view of the loading and unloading device of FIG. 24;

(32) FIG. 28 is another perspective view of the loading and unloading device of FIG. 24 showing the carriage and pivotal arms moved away from the fully stowed position;

(33) FIG. 29 is yet another perspective view of the loading and unloading device of FIG. 24;

(34) FIG. 30 is a perspective view of another embodiment of a cot fastening system incorporating aspects of the present invention;

(35) FIG. 31 is a side elevation view of a cargo area of an ambulance with an ambulance cot loading and unloading apparatus according to another embodiment of the present invention mounted therein illustrating the loading and unloading apparatus in a deployed configuration;

(36) FIG. 32 is a plan view of the loading and unloading apparatus of FIG. 31 shown with a trolley and a transfer track moved to their fully retracted stowed positions; track;

(37) FIG. 33 is a similar view to FIG. 32 showing the trolley extended along the transfer

(38) FIG. 34A is an exploded perspective view of the mounting arrangement of the trolley latch assembly mounted to the base of the loading and unloading system of FIG. 31;

(39) FIG. 34B is an exploded perspective view of the mounting of the primary coil at the cot anchor location along the base of the inductive recharging system of the embodiment of FIG. 31;

(40) FIG. 34C is an exploded perspective view of the primary coil mounting bracket;

(41) FIG. 34D is a perspective view of the base illustrating the mounting details of a release trigger assembly;

(42) FIG. 35 is an exploded perspective view of the trolley anchor assembly of the loading and unloading system of FIG. 31;

(43) FIG. 36 is an exploded perspective view of a foot end fastener assembly of the cot of FIG. 31;

(44) FIG. 37 is an exploded perspective view of the mounting details of the trolley secondary control of the loading and unloading system of FIG. 31;

(45) FIG. 38 is a diagram showing the arrangement and relationship between FIGS. 38A, 38B, 38C, and 38D, which together illustrate a schematic drawing of the control system of the ambulance cot and loading and unloading system of FIG. 31;

(46) FIG. 38A is a first portion of the diagram referenced by FIG. 38;

(47) FIG. 38B is a second portion of the diagram referenced by FIG. 38;

(48) FIG. 38C is a third portion of the diagram referenced by FIG. 38; and

(49) FIG. 38D is a fourth portion of the diagram referenced by FIG. 38.

#### DETAILED DESCRIPTION OF THE CURRENT EMBODIMENT

(50) The present invention will now be described with reference to the accompanying drawings wherein the reference numerals appearing in the following written description correspond to like-numbered elements in the several drawings. A diagram of a patient support apparatus 20 that may incorporate one or more aspects of the present invention is illustrated in FIG. 1. In section A below, a more detailed description of the various components that may be present on patient support apparatus 20 when it is used within a medical care setting is provided. In sections B and C, a more detailed description of the various components that may be present on a patient support apparatus intended primarily for use in a vehicle, such as an ambulance, helicopter, or the like, is provided. It will, however, be understood by those skilled in the art that any of the features of the patient support apparatuses described in sections A, B, or C can be incorporated into the patient support apparatuses described in any of the other sections herein.

(51) A. Patient Support Apparatuses

(52) As shown in FIG. 1, patient support apparatus 20 includes a base 22, a pair of elevation assemblies 24a-b, a patient support deck 26, a frame 28, a headboard 30 positioned at a head end 32 of patient support apparatus 20, and a footboard 34 positioned at a foot end 36 of patient support apparatus 20. Base 22 includes a plurality of wheels 35 that may be selectively braked and unbraked to thereby facilitate movement of patient support apparatus 20. Patient support apparatus 20 may be a bed, a stretcher, a cot, a surgical table, a gurney, a chair, or any other type of support that is used for supporting a patient in a healthcare setting.

(53) Deck 26 of patient support apparatus 20 is adapted to support a mattress 38 (FIG. 2) on which a patient may lie. Deck 26 is, in the illustrated embodiment, divided into a plurality of sections, including a head section 40, a seat section 42, a thigh section 44, and a foot section 46. It will be understood by those skilled in the art that the number of sections into which deck 26 may be divided may be fewer or greater than the four sections shown in FIG. 1. In the embodiment of FIG. 1, head section 40 is pivotable about a horizontal pivot axis 48 that extends vertically out of the plane of FIG. 1. One or more actuators, not shown, may be included that enable head section 40 to pivot about axis 48. Additional actuators may also be provided for allowing other sections of deck 26 to pivot and/or move.

(54) FIGS. 2-3 illustrates another embodiment of a patient support apparatus 20 that may incorporate one or more aspects of the present invention. Patient support apparatus 20 also includes a base 22, a plurality of elevation assemblies 24a-d, a support deck 26, a headboard 30, a footboard 34, and a mattress 38. Unlike the embodiment shown in FIG. 1, the embodiment of FIG. 2 does not include a frame 28 or a thigh section 44. Each section of deck 26 in the embodiment of FIG. 2 may include a plate (not shown) or other flat structure positioned on top of it that helps support a mattress or other type of sleep surface on which a patient lies. Head section 40 is configured to support the head and torso region of a patient lying on support deck 26. Seat section 42 is configured to support the buttocks region of a patient lying on support deck 26. And foot section 46 is configured to support the foot and lower leg region (e.g. the region of the leg below the knee) of a patient lying on support deck 26. It will be understood, however, that the precise line of demarcation between the various deck sections can be varied within the present invention to align with different portions of the patient's body.

(55) For any of the patient support apparatuses described herein, one or more control panels (e.g. control panel 92 of FIGS. 4A and 4B) may be included on patient support apparatus 20 that include buttons, knobs, switches, touch screens, or other types of controls that enable a patient and/or a caregiver to control the pivoting of head section 40 about axis 48. Such control panels may also include a number or other controls for controlling various other aspects of patient support apparatus 20. Such additional controls may include controls for raising and lowering the height of frame 28 (or deck 26 in the embodiment of FIGS. 2-3) relative to base 22, pivoting and/or moving any of the other sections of deck 26 (e.g. seat section 42, thigh section 44, or foot section 46), arming a bed exit alert, weighing a patient while positioned on support apparatus 20, communicating with a nurse call system, and for performing still other functions.

(56) In some embodiments, mattress 38 may be a mattress that includes one or more internal fluid bladders that may be selectively inflated to different pressures for providing maximum comfort to a patient positioned thereon, as well as for performing various therapies on the patient. Such mattresses typically include a blower or pump that is controlled by suitable electronics within the mattress. The blower or pump is controlled to change or maintain the fluid pressure within the various bladders in whatever manner is desirable. In many instances, one or more manifolds are included within mattress 38 so that different sections of the mattress can be controlled individually.

(57) The actuators and controls on the patient support apparatus 20, as well as the controls and blower inside mattress 38, are typically powered by electricity. Patient support apparatus 20 includes a power cable (not shown) that plugs into a conventional electrical wall outlet for receiving electrical power therefrom. In some embodiments, support apparatus 20 may include one

or more batteries that enable the support apparatus to maintain some, or all, of its electrical functions while its power cable is disconnected from the electrical wall outlet. Such uses of battery power are typical when support apparatus **20** is being moved from one location to another.

(58) In order to provide electrical power to the control circuitry within mattress **38**, patient support apparatus **20** may include an inductive coupler **50** (FIGS. 7 and 8). Inductive coupler **50** includes a patient support housing **52** and a mattress housing **54**. Patient support housing **52** is integrated into, or attached to, patient support apparatus **20**. Mattress housing **54** is integrated into, or attached to, mattress **38**. Patient support housing **52** is configured to house one or more patient support coils **56** (FIGS. 13A-C). Mattress housing **54** is configured to house one or more mattress coils **58**. Each housing **52** and **54** is positioned on its respective component (support apparatus **20** and mattress **38**) at a location such that they will be aligned with each other when mattress **38** rests on patient support deck **26**.

(59) In the embodiment shown in FIGS. 4 and 5, inductive coupler **50** is positioned on foot section **42** of deck **26**. It will be understood by those skilled in the art that inductive coupler **50** may be positioned at other locations. Such locations may include being built into either of footboard **34** or headboard **30**, or in other locations. To the extent the control circuitry and/or blower of the mattress **38** is positioned near the foot end of mattress **38**, it may be beneficial to position inductive coupler **50** near the foot end of mattress **38** so that it is positioned closely to the electrical components inside of mattress **38**.

(60) Inductive coupler **50** is adapted to inductively supply electrical power from patient support apparatus **20** to mattress **38**. The inductive transfer of electrical energy from patient support **20** to mattress **38** may be carried out by a controller **60** (FIGS. 13A-13C) positioned on patient support apparatus **20** that runs a changing electrical current through patient support coil **56**. This creates a changing magnetic field around coil **56** that, when mattress coil **58** is closely positioned nearby, induces a changing electric field within coil **58**, thereby creating electrical current within mattress coil **58** and the electrical circuit it is coupled to. A mattress controller **62** harnesses the electrical energy inductively generated within mattress coil **58** for providing electrical power to the electrical components of mattress **38**. Such electrical components, in addition to the blower and/or pump within mattress **38**, may include valve actuators, sensors, control circuits (including those within controller **62**), and a battery **64**.

(61) FIGS. 5-10 illustrate in greater detail the physical construction of one embodiment of inductive coupler **50**. It will be understood by those skilled in the art that the physical configuration of inductive coupler **50** may be changed from that shown and described herein. As shown in FIGS. 5, 7-8, and 9-10, patient support housing **52** includes a base **66**, a circular wall **68** that extends upwardly from base **66**, a top wall **70**, and a rectangular coil wall **72** that is positioned on top of top wall **70**. Rectangular coil wall **72** includes a pair of end walls **74** positioned opposite each other, and a pair of side walls **76** positioned opposite each other. Mattress coil **58** fits within an interior region **78** defined within rectangular coil wall **72**. As can further be seen in FIGS. 7-10, a sloped interior surface **80** is defined on the interior of housing **52** that extends from base **66** up to an underside of top wall **70**. Sloped interior surface **80** is dimensioned and sloped to matingly receive a similarly sloped projection surface **82** of patient support housing **52**.

(62) FIGS. 6-10 illustrate in greater detail the physical construction a patient support housing **52** that is designed to matingly and selectively engage with mattress housing **54** of FIGS. and 7-10. Patient support housing **52** includes a base **84** and a top surface **86** that are separated from each other by sloped projection surface **82**. A coil space **88** is defined within patient support housing **52** and dimensioned such that patient support coil **56** may fit therein. As can be seen in FIG. 8, coil space **88** is positioned such that it vertically aligns with interior region **78** of mattress housing **54**. Thus, mattress coil **58** and patient support coil **56** will be aligned with each other, and very closely positioned to each other, when housing **52** is inserted into housing **54**.

(63) As can also be seen in FIGS. 5-10, sloped interior surface **80** and sloped projection surface **82**

are not radially symmetrical about vertical axis. Instead, surfaces **80** and **82** are elongated such that housings **52** can only fit together in one of two manners—the one shown in FIGS. **7-10**, or one in which either of housings **52** or **54** (but not both) are rotated 180 degrees about a vertical axis. In practice, this 180 degree rotation will not occur because such a rotation would require the mattress **38** (to which housing **54** is coupled) to be rotated 180 degrees which, in turn, would cause the mattress **38** to be positioned primarily off of patient support apparatus **20**. Thus, the relative shapes of housings **52** and **54** ensure that the coils contained therein (**56** and **58**) can only be oriented in one possible orientation with respect to each other, which is the desired orientation for the effective inductive transfer of energy to mattress **38**.

(64) The sloped nature and dimensions of surfaces **80** and **82** also help ensure that housings **52** and **54** align with each other when mattress **38** is positioned on support deck **26**. If the alignment is slightly off, the sloped surfaces will act as cam surfaces that translate the downward gravitational force on the mattress **38** (or other downward force exerted onto mattress **38**) into a horizontal force, urging the mattress to slide in the needed direction for alignment of housings **52** and **54**. When properly aligned, projection surface **82** fits completely within the interior space defined by sloped interior surface **80** of mattress housing **54**. This alignment causes top wall **86** of patient support housing **52** to touch, or nearly touch, the underside of top wall **70** of mattress housing **54**.

(65) The sloped projection surface **80** of patient support housing **52** and the sloped interior surface **82** of mattress housing **54** are generally smooth, non-porous surfaces that are free from crevices, grooves, indentations, or other sharp changes in topology. This facilitates the cleaning and/or sterilization of both mattress **38** and patient support apparatus **20**.

(66) As can also be seen in FIGS. **6-9**, patient support housing **52** also includes an LED (light emitting diode) tube **90**. Tube **90** provides a space for either positioning an LED, or an optically conductive material for transferring light from an LED positioned adjacent tube **90** to the exterior of housing **52**. In either case, light emitted from the LED is visible to a caregiver when mattress housing **54** is lifted off of patient support housing **52** (e.g. FIG. **4A**). The LED may be lit to provide an indication that controller **60** is operable and functioning properly. This LED light may be emitted at all times while controller **60** is functioning properly. In other embodiments, patient support apparatus **20** may be configured such that a caregiver has to manipulate a control on apparatus **20** (such as a button, or the like) in order to turn on the inductive coupling feature. In such embodiments, the LED light will only illuminate when the inductive coupling feature is turned on, assuming controller **60**—and any other components necessary for the inductive transfer of electrical energy to mattress **38**—are functioning properly. LED light therefore provides diagnostic information to a user. If, for example, electrical energy is not being inductively transferred to mattress **38**, but the LED light is illuminated, this would suggest that the failure of inductive energy transfer is due to a component within mattress **38**, not due to a component within patient support apparatus **20**.

(67) Controller **60** (FIGS. **13A-13C**) may be configured, in at least one embodiment, to automatically detect when housings **52** and **54** are matingly engaged with each other. Such automatic detection may occur by driving the patient support coil **56** with a known current or voltage and then sensing the actual current or voltage that is generated within coil **56**, including the phase relationship therebetween and any changes in such phase relationship. Changes in the current, voltage, and/or phase relationship will occur depending upon whether or not mattress coil **58** is positioned adjacent coil **56** or not. Controller **60** may sense these differences and provide an indication to the caregiver when the engagement of mattress housing **54** with patient support housing **52** is detected. Controller **60** may further be configured to provide a humanly-perceptible indication of this successful engagement. The indication may be aural, visual, or a combination of aural and visual indications.

(68) In one embodiment, a control panel **92** (FIGS. **4A** and **4B**) positioned on footboard **34** may include a light that illuminates when housings **52** and **54** are successfully engaged with each other.

Alternatively, control panel **92** may include a display screen that includes an icon or other graphics that indicate the successful engagement of housings **52** and **54**. The control panel **92**, in some embodiments, may be a menu driven control panel that includes a menu of graphics and/or screens that are specifically designed for controlling the operation of mattress **38**. In some embodiments, a graphic indication may be provided that indicates the degree of electrical charge within battery **64** of mattress **38**. Such a graphic may be displayed to indicate the progress of re-charging battery **64** through inductive coupler **50**.

(69) In some embodiments, control panel **92** may be built into patient support apparatus and include other menus and/or controls for controlling any of the other functions of patient support apparatus **20**. In other embodiments, control panel **92** may be part of a pendant, or other device, that is not an integral part of patient support apparatus **20**, but which may be selectively coupled and decoupled thereto. Control panel **92** may receive data from mattress controller **62** (or another controller on mattress **38** that is in communication with mattress controller **62**) by way of a wireless communication channel that will be discussed in greater detail below.

(70) FIGS. **14-17** illustrate one embodiment of a mattress control box **94** that is designed to house the blower or pump of mattress **38**, as well as mattress controller **62**, any associated electronics, a fluid manifold, and any other components used in controlling the inflation and deflation of one or more sections of mattress **38**. Mattress control box **94** includes a base wall **94** to which mattress housing **54** is affixed. The size and shape of control box **94** may be varied from that shown and should be suitably dimensioned to house the desired components of mattress **38**. Mattress control box **94** is also shaped to be received within a similarly shaped recess (not shown) within mattress **38**. In some embodiments, the underside of base wall **94** will be exposed when mattress **38** is covered by a sheet, or other suitable covering. In other embodiments, mattress **38** may be entirely covered by a sheet, or other flexible covering, thereby also covering the underside of mattress control box **94**. In this latter case, the sheet or flexible covering will interpose itself between top surface **86** of patient support housing **52** and the underside of top wall **70** of mattress housing **54**, but this thin layer of material will not prevent the inductive transfer of electrical energy from patient support apparatus **20** to mattress **38**.

(71) As shown in FIGS. **15-16**, a pair of wires **98** are electrically coupled to patient support coil **56**. While not shown in these figures, wires **98** electrically couple patient support coil **56** to patient support controller **60**. Similarly, a pair of wires **100** electrically couple mattress coil **58** to mattress controller **62**.

(72) Any of the patient support apparatuses described herein—such as, but not limited to, support apparatus **20**—may include an electrical communication network **102**, such as is shown in FIGS. **11, 12, and 18**. Electrical communication network **102** enables electrical messages to be sent to and received from various nodes or electronic control circuits on patient support apparatus **20**. The embodiment of FIG. **11** illustrates such a communication network **102** having five nodes. The embodiment of FIG. **12** illustrates such a communication network **102** having four nodes. And the embodiment of FIG. **18** illustrates such a communication network **102** having six nodes. It will be understood by those skilled in the art that the number of nodes may be fewer or greater than what is shown in FIGS. **11, 12, and 18**. It will also be understood that the numbering of the nodes in FIGS. **11-12 and 18** is arbitrary, and that the functions described for various of the nodes have been done for illustrative purposes only. That is, the functions of various of the nodes may be changed and/or combined with other nodes and/or eliminated in some embodiments of patient support apparatus **20**.

(73) Electrical communication network **102** may be a controller area network (CAN), or it may be another type of communication network. Such other types may include LONWorks, LIN, RS-232, DeviceNet, or still other types of networks. The network may include only the two network layers of CAN, or it may include more than two layers, such as CANOpen.

(74) Each node typically includes a circuit board that contains the electronics necessary for



controlling a user interface, one or more actuators, one or more sensors, and one or more other electrical components. For example, in FIGS. **11-12** and **18**, node **#1** is configured to control a user interface. The user interface may include one or more buttons or switches, or the like, or it may include a touch screen, or other device for allowing a patient or caregiver to control one or more aspects of patient support apparatus **20**. Node **#2** is shown to interact with one or more sensors. Such sensors may include load cells for measuring the weight of a patient positioned on support apparatus **20**, and/or it may include one or more sensors for detecting the activation of the brake, and/or angle sensors for detecting the angular orientation of one or more components of support apparatus **20**, such as the head section **40** of support deck **26**. Node **#2** is responsible for processing the outputs of these sensors and forwarding messages containing the sensed information to the network **102**.

(75) In the illustrated embodiment, node **#3** is provided for controlling one or more motors, actuators, and/or the brake of patient support apparatus **20**. Node **#4** is shown controlling inductive coil **56** of patient support apparatus **20**. Node **#4** includes patient support controller **60**, as well as the associated electronic necessary for allowing controller **60** to communicate with network **102** (and any other suitable or desired electronics). In the illustrated embodiment of FIG. **11**, a fifth node (node **#5**) is provided that manages wireless communication between patient support apparatus **20** and mattress **38**. An alternative embodiment of network **102** is shown in FIG. **12** in which the functions of nodes **#4** and **#5** of FIG. **11** is combined into a single node (node **#4** of FIG. **12**). Node **#4** of FIG. **12** therefore not only controls the inductive transfer or electrical energy from patient support apparatus **20** to mattress **38**, it also controls the wireless communications between patient support apparatus **20** and mattress **38**. A more detailed description of one embodiment of node **#4** of FIG. **12** is provided below and shown in FIGS. **13A-13C**.

(76) Mattress **38** is depicted diagrammatically in FIGS. **11-12** and **18**. Mattress **38** includes mattress coil **58**, a blower **104** (which may be a pump), and controller **62**. Controller **62** is in electrical communication with both mattress coil **58** and blower **104**. Additional structures may be included within mattress **38** that have been omitted from FIGS. **11-12** and **18**, such as battery **64**, a fluid manifold, one or more other controllers, and other components.

(77) In the embodiments of FIGS. **11** and **12**, mattress **38** and patient support apparatus **20** communicate with each via a wireless communication link **106**. Link **106** includes a mattress antenna **108** and a patient support antenna **110**. A wireless transceiver **112** is also included on patient support apparatus **20**. Another wireless transceiver (not shown) is included within mattress, such as within control box **94**. The wireless link **106** may be a Bluetooth connection, a ZigBee connection, a RuBee connection, a WiFi (IEEE 802.11) connection, an infrared (IR) connection, or any other suitable wireless communication connection.

(78) Patient support controller **60** and mattress controller **62** may communicate mattress control data, as well as status data, over wireless communication link **106**. In other embodiments, such mattress control and status data may be transferred by other controllers that are in communication with link **106**. Regardless of the specific components transferring such information, the mattress control data may include commands that are entered on one of the control panels, such as control panel **92**, of patient support apparatus **20** for controlling mattress **38**. Thus, for example, a caregiver may use control panel **92** to enter commands for changing the inflation pressure inside of one or more fluid bladders of mattress **92**. The control panel will communicate those commands to controller **60**, or another controller, via communication network **102**. Controller **60**, or another controller, will then wirelessly transmit those commands via wireless link **106** to mattress controller **62**, or to another controller on mattress **38**. In this manner, it is possible to control mattress **38** via patient support apparatus **20** without any wires, cables, or other physical coupling between support apparatus **20** and mattress **38**. Similarly, because of the inductive transfer of energy to mattress **38** from support apparatus **20**, there is no need for any power supply wires, cables, or other physical connections between mattress **38** and support **20** for supplying electrical

power. The combination of inductive power transfer and wireless communication therefore enables mattress **38** to be completely separable from patient support apparatus **20**. This eliminates the need for caregivers to physically couple any cables or the like from mattress **38** to patient support **20** before using mattress **38**. Similarly, this eliminates the need for caregivers to physically disconnect any cables or the like from mattress **38** when mattress **38** is removed.

(79) Mattress controller **62** may be in communication with one or more sensors on mattress **38**, such as, but not limited to, pressure sensors and/or a battery level sensor. Mattress controller **62** may transmit the readings from these sensors, or data related to the readings from these sensors, to patient support controller **60** by way of link **106**. Patient support controller **60** may then display this information to a caregiver on one or more control panels positioned on patient support apparatus **20**. Controller **60** may communicate this information to the display directly, or by way of network **102**. In an alternative, the sensors on mattress **38** may communicate their data to a separate controller on mattress **38** that then transmits this information via wireless link **106** to patient support apparatus **20**.

(80) Patient support controller **60** may also communicate via link **106** with one or more sensors and/or sensing sheets that may be placed on or in mattress **38**, and which may not be in direct communication with mattress controller **62**. Examples of one type of sensing sheet that may wirelessly communicate via link **106** with patient support apparatus **20** are disclosed in commonly assigned U.S. provisional patent application Ser. No. 61/546,546 filed Oct. 12, 2011 by applicant Geoffrey Taylor and entitled Pressure Sensing Mat, the complete disclosure of which is hereby incorporated herein by reference. Controller **60** may also communicate via link **106** with any of the sensing sheets disclosed in commonly assigned U.S. provisional patent application Ser. No. 61/449,182 filed Mar. 4, 2011, by applicant Richard Derenne and entitled Sensing System for Patient Supports, the complete disclosure of which is also hereby incorporated by reference herein. When communicating with any of the mattress sensors and/or sensor sheets disclosed in these applications, controller **60** may communicate information from the mattress sensors and/or sensing sheet to communication network **102**. Any appropriate node on network **102** may then use this information in carrying out its intended function. For example, if the sensing sheet detects an undesired amount of pressure being exerted on a specific portion of the patient, a node (such as node #3) may automatically be programmed to change the orientation of one or more of deck sections **40-46** to try to alleviate such pressure. The data sensed by the mattress sensors and/or sensing sheet may also be transmitted off of patient support apparatus to a remote location, such as a server, or other computer, that forwards the information to an electronic medical record, a caregiver alerting system, a work flow system, an admission, discharge, and transfer (ADT) system, or any other suitable system. In such embodiments, network **102** may include an additional node (not shown) for managing such remote communication.

(81) In another embodiment, controller **60** may be configured to change the pressure inside one or more bladders of mattress **38** in response to data received from any of the sensing sheets disclosed in applications 61/546,546 or 61/449,182. For example, if controller **60** receives information from one of these sensing sheets that a patient is experiencing undesired interface pressure at a specific region on his or her body, controller **60** may then issue one or more commands via link **106** to mattress controller **62** to change the inflation of one or more bladders within mattress **38**.

Algorithms for changing the inflation of mattress **38** based upon sensed patient interface pressure are disclosed in, for example, commonly assigned U.S. patent application Ser. No. 12/075,937 filed Mar. 15, 2008 by applicant Geoffrey Taylor and entitled Adaptive Cushion Method and Apparatus for Minimizing Force Concentrations on a Human Body, the complete disclosure of which is hereby incorporated herein by reference.

(82) FIGS. **13A-C** illustrate in greater detail the electronic components that may make up patient support controller **60** and mattress controller **62**. In the embodiment of FIGS. **13A-C**, controllers **60** and **62** also manage the communications via link **106**. However, as has been noted (and illustrated

in FIG. 11), a separate controller may be used for managing communications between mattress **20** and patient support apparatus **38**, if desired. As will be recognized by those skilled in the art, additional components beyond those shown in FIGS. 13A-C may also be added to either or both controllers **60** and **62** for controlling other aspects of either the patient support apparatus **20** or mattress **38** beyond the wireless power transfer and/or wireless data transfer.

(83) Patient support controller **60** includes an AC to DC power converter **120** that converts the AC power received from a conventional electrical outlet to DC power. The DC power may be any suitable voltage. In one embodiment, the DC power may be 24 volts. In other embodiments, this voltage may be different. Further, in at least one embodiment, AC to DC power converter **120** also supplies DC power to all, or at least some, of the other electrical components on patient support apparatus **20**. In this manner, patient support apparatus **20** may only have a single AC to DC power converter, instead of multiple AC to DC power converters.

(84) Power converter **120** feeds DC power to a suitable microcontroller **122** for controlling the operation of patient support coil **56**, as well as managing communications over wireless link **106**. Microcontroller **122** controls a bridge controller **124** and a field effect transistor (FET) driver **126** that, in combination, generate an AC signal for driving patient support coil **56**. A current sensing circuit **128** senses the current flowing through coil **56** and passes its output to a phase sense and voltage follower circuit **130**. Phase sense and voltage follower circuit **130** analyzes any shift in the current flowing through coil **56**. This analysis may be used to automatically detect whether or not mattress coil **58** is adjacent to coil **56** or not. That is, controller **60** may periodically ping coil **56** to determine if coil **58** is adjacent or not. Such pinging may take place multiple times a second until coil **58** is detected. Once detected, the phase analysis performed by circuit **130** may be used to monitor whether coil **58** remains in near proximity to coil **56** or not.

(85) The pinging of coil **56** may take place multiple times a second. Such pinging may involve driving coil **56** with a small amplitude wave of electrical current and monitoring the relationship between the phase and current in coil **56** by circuit **130**. Depending upon the phase relationship, the presence or absence of mattress coil **58** can be inferred, as would be known to one of ordinary skill in the art. The amount of current used in pinging coil **56** may be substantially less than that which flows through coil **56** during inductive energy transfer. This reduces power consumption, as well as electromagnetic interference with other electrical or electronic devices. The duration of a single current ping may also be less than a single cycle time used during inductive charging. In other words, the current used during pinging is less than that used during a single cycle of inductive coupling, and it also may last for less time than the length of a single inductive coupling cycle.

(86) The output of circuit **130** is fed to a current limiting control circuit **132** that, in conjunction with microcontroller **122**, limits the current flowing through coil **56**. This current limiting may be used to prevent undesired and/or excessive amounts of current flowing through coil **56**, as well as in limiting the amount of current that is used during the pinging process described above.

(87) Microcontroller **122** is also in communication with a network transceiver **134**, which, in the embodiment shown in FIGS. 13A-C is a CAN transceiver. As noted, however, it will be understood that other types of networks may be used on the patient support apparatuses discussed herein. Network transceiver **134** is in electrical communication with network **102**, as well as wireless transceiver **112**. As shown in FIG. 12, wireless transceiver **112** may be an RF transceiver or an IR transceiver.

(88) One embodiment of a mattress controller **62** is also depicted in more detail in FIGS. 13A-C. Mattress controller **62** includes a coil secondary side circuit **136** that is in direct electrical communication with mattress coil **58**. Coil secondary side circuit **136** passes its output onto a resonant filter and bridge diode rectification circuit **138** that filters and rectifies the AC current coming from coil **58**. The output of filter and rectifier circuit **138** is sequentially fed to a voltage regulation circuit **140** and current sensing circuit **142**. The current sensing circuit sensing the amount of current and forwards this information to a microcontroller **144**. The current sensing

circuit **142** also passes the current generated by coil **58** to a charging switch **145** that selectively couples the current to battery **64** for charging and recharging battery **64**. Charging switch **145** is controlled by a battery charge and current limiting control circuit **146** that is, in turn, controlled by microcontroller **144**. The circuitry of mattress controller **62** thereby allows microcontroller **144** to oversee and control the inductive transfer of electrical energy from coil **56** to coil **58**, and to use that electrical energy for charging battery **64**.

(89) It will be understood by those skilled in the art that battery **64** is an optional component. In some embodiments, battery **64** may be omitted and controller **62** may be configured to supply electrical energy directly to all of the electrical consumers on mattress **38**. This supply of electrical energy will only occur substantially at the time when mattress **38** is inductively coupled to patient support apparatus **20**. It will also be understood that the electrical source of power for patient support apparatus controller **60** (and coil **56**) could be a battery carried on board patient support apparatus **20**, thereby allowing patient support apparatus **20** to inductively supply electrical energy to mattress **38** even when the electrical power cord of patient support apparatus is not plugged into an electrical outlet.

(90) Mattress controller **62** of FIGS. **13A-C** further includes a network transceiver **148** that is in communication with a wireless transceiver **150**. Network transceiver **148** is an optional component that may be omitted in some embodiments. Network transceiver may be desirably used in those situations where a manufacturer of mattresses or mattress controllers has a pre-existing mattress controller design that is adapted to received instructions via a specified electronic communication format. The use of network transceiver **148** allows the pre-existing design for a wired communication mattress controller to be maintained and used within mattress controller **62** without having to re-program the pre-existing wired communication mattress controller. That is, network transceiver **148** may be chosen so that it communicates with microcontroller **144** in the same manner as pre-existing wired microcontrollers communicated with a mattress microcontroller. In the embodiment shown in FIGS. **13A-C**, network transceiver **148** is a CAN transceiver, although it will be understood that different types of network transceivers may be used. Also, as noted, network transceiver **148** could be omitted in some embodiments, in which case wireless transceiver **150** may communicate directly with microcontroller **144**.

(91) By supplying inductive electrical power to mattress **38**, patient support apparatus **20** eliminates the need for power cords running between mattress **38** and patient support apparatus **20**. The size of mattress control box **94** may also be reduced because various electrical components, such as a transformer, that were present in prior wired mattress controllers can be eliminated. The elimination of both power and data cables between mattress **38** and patient support apparatus **20** also eliminates the potential for damage to such cables and/or the circuitry connected thereto that was present in prior art designs. Such damage could occur when attempting to lift or remove a mattress from a patient support deck **26** without first unplugging the cables. Further, because such cables do not need to be unplugged in the present design, cleaning underneath mattress **38** is easier because mattress **38** only needs to be lifted, instead of both unplugged and lifted, as in the prior art.

(92) In the illustrated embodiment, patient support controller **60** is configured to supply up to 120 watts of power to mattress **38**. Other amounts of energy can also be inductively transferred. Controller **60** may also be configured to terminate power to coil **56** when no mattress **38** is present, or if mattress housing **54** is not aligned with patient support housing **52**. In some embodiments, as was noted, controller **60** may periodically check for the presence of mattress **38**, and if it is not found, no current will be supplied to coil **56**. This eliminates or reduces the likelihood of coil **56** causing undesired electromagnetic interference with any nearby electronic devices. When mattress **38** is present and housings **52** and **54** are aligned, controller **60** may be configured to automatically begin transferring power to mattress **38**, or it may await a prompt from a user indicating such transfer should occur. In one embodiment, mattress controller **62** may automatically terminate current to coil **56** when battery **64** is fully charged. In another embodiment mattress controller **62**

may automatically terminate current to coil **56** only when mattress **38** is not consuming any, or any significant amounts of, electrical energy, and battery **64** is fully charged. Controller **60** may receive information about the charge status of battery **64** and/or the electricity usage of mattress **38** via wireless link **106**.

(93) FIG. **18** illustrates another embodiment of the electrical components that may be present on a patient support apparatus according to one or more aspects of the present invention. The network **102** of FIG. **18** is the same as the network **102** of FIG. **11** with the sole exception of the addition of node #**6** and a support apparatus inductive coil **154** controlled by node #**6**. The electronics of FIG. **18** may be used on a patient support apparatus that has the ability to inductively receive electrical energy from a stationary source, such as an inductive power station **182** (FIGS. **19** and **20**). This eliminates the need for the patient support apparatus **20** to have an electrical cable for plugging the apparatus **20** into a conventional electrical outlet. Or, in some embodiments, this gives the support apparatus the ability to either receive electrical energy inductively through power station **182**, or to be plugged into an electrical wall outlet if no inductive power station **182** is present, or if it is not desired to use inductive power station **182**. Node #**6** controls coil **154** to draw power therefrom that is then used to power the electrical components on patient support apparatus **20**. In addition to the components shown in FIG. **18** and/or discussed herein, the patient support apparatus **20** may include one or more rechargeable batteries that are recharged by the inductive power received through coil **154**. This enables support apparatus **20** to be moved away from station **182** while still having a source of electrical energy. When moved away from station **182**, the battery or batteries on board patient support apparatus **20** may be used to supply electrical energy to coil **56** for transfer to mattress **38**.

(94) FIGS. **19** and **20** illustrate two different embodiments of a power station **180** that may be positioned on a floor **182** adjacent a vertical wall **189**. Power station **180** includes a coil **186** through which an alternating current is passed. Coil **186** may be positioned underneath a top surface of floor **182** so as to not be a trip hazard. When it is desirable to receive electrical power from power station **180**, the patient support apparatus (such as, but not limited to, apparatus **20**) is wheeled to a location such that its inductive power receptor is positioned vertically above coil **186**. The alternating current passed through coil **186** creates a changing magnetic field that induces a voltage on a secondary coil, such as coil **154**, within the inductive power receptor on the patient support apparatus. This induced voltage drives a current that may be used to power any of the various electrical systems on the patient support apparatus, or to re-charge a battery, or both.

(95) In an alternative inductive power station **180'**, a conductive plate **188** is positioned on or underneath floor **182**. Plate **188** is coupled to a source of alternating current such that it radiates an electromagnetic wave that induces a voltage on a coil or plate positioned on the patient support apparatus. Plate **188** or coil **186** can thus be used to wirelessly transmit power from stations **180** or **180'** to a mobile patient support apparatus, such as patient support apparatus **20'**.

(96) FIG. **3** illustrates one suitable location on patient support apparatus **20** for inductive coil **154**. In some embodiments, it may be desirable to have inductive coil **154** positioned closer to coil **186** or plate **188** than it otherwise would be if coil **186** were immovably mounted to patient support apparatus **20**. To that end, an actuator (not shown) may be physically coupled to coil **186** to selectively extend and retract coil **186** toward and away from coil **186** and/or plate **188**. Such actuation may be responsive to a user manipulating a control on patient support apparatus **20**. In one embodiment, the extension of coil **186** may automatically occur each time the brake is activated on patient support apparatus **20**, and the retraction of coil **186** may automatically occur each time the brake is deactivated on patient support apparatus **20**. In another embodiment, control circuitry on-board patient support apparatus **20** that is in electrical communication with coil **154** may automatically detect the presence of a power station **180** or **180'** and automatically extend coil **156** when such presence is detected. In still other embodiments, coil **186** or plate **188** may be extended and retracted toward and away from patient support apparatus **20** while coil **154** remains

stationary on apparatus **20**. In still other embodiments, both the coil **154** and the coil **186** or plate **188** of power station **180** or **180'** may extend and retract toward each other so as to increase the efficiency of the inductive electrical energy transfer therebetween.

(97) It will be understood by those skilled in the art that, in some embodiments, patient support apparatus **20** may only include the inductive coil **154** and not the coil **56**. In such embodiments, patient support apparatus **20** inductively receives the power it needs, but does not have the ability to inductively transfer electrical energy to any mattress **38** positioned thereon. Power to such a mattress may be supplied by an electrical cable, and communication may take place either wirelessly or by a data cable. In other embodiments (e.g. FIG. **18**), patient support apparatus **20** may include both coil **154** and coil **56**, thereby both inductively receiving power and inductively transferring power to mattress **38**. In still other embodiments (e.g. FIGS. **11** and **12**), patient support apparatus **20** may include only patient support coil **56**, but not coil **154**, thereby enabling it to inductively transfer power to mattress **38**, but not inductively receive any power itself.

(98) It will further be understood by those skilled in the art that, although FIG. **19** illustrates only a single loop of coil **186**, additional loops and/or additional coils may be present. Indeed, in some embodiments, power station **180** may include multiple coils **186**. Such coils may be spread out over a large area relative to coil **154** of patient support apparatus **20**. By having coils **186** spread out over a large area, it is not necessary for coil **154** to be precisely aligned with a single location relative to power station **180** in order for efficient inductive energy transfer to take place. In some embodiments, coil **186** may be large enough to accommodate multiple patient support apparatuses **20**. Still further, in some embodiments power station **180** may include multiple coils **186** that may each be individually controlled. A controller for power station **180** may automatically detect which coils **186** are closest to support coil **154** and selectively energize only those coils, thereby reducing unwanted generation of electromagnetic interference.

(99) B. Vehicular Patient Support Apparatuses

(100) Any one or more of the aspects of the patient support apparatuses described above with respect to FIGS. **1-20** may be used in whole, or in part, in any of the vehicular patient support apparatuses and/or loading/unloading systems described below with respect to FIGS. **21-38**. Some components of the patient support apparatuses are described in more detail in U.S. Pat. No. 7,887,113, which is incorporated by reference herein. The reference numbers in FIGS. **21-30** correspond to the reference numbers in the U.S. Pat. No. 7,887,113 patent but have been increased by 400. Thus, for example, the reference number **10** in the '113 patent corresponds to reference number **410** herein.

(101) Referring to FIG. **21**, the numeral **410** generally designates a patient support that may incorporate one or more aspects of the present invention. In the illustrated embodiment, patient support **410** comprises a cot, such as an ambulance cot or emergency stretcher. For details of the overall structure of a suitable cot or stretcher that may incorporate the present invention, reference is made to U.S. Pat. Nos. 5,537,700; 6,125,485; 6,735,794; 7,100,224; WO2004/064698; U.S. Patent Publication 2006/0075558, and co-pending U.S. patent application Ser. No. 10/542,232, for example, all commonly assigned to Stryker Corporation of Kalamazoo, Mich. and which are incorporated by reference in their entireties herein. As will be more fully described below, patient support **410** is secured in an emergency vehicle **412** by a cot or patient support fastening system. Further, each of the patient support **410** and the fastening system may include a rechargeable power supply, such as a rechargeable battery, that can be recharged by a power supply at the vehicle, including the vehicle's battery.

(102) In the illustrated embodiment, the cot fastening system comprises a loading and unloading device **414** that loads patient support **410** into and unloads patient support **410** from the emergency vehicle, as well as fastens patient support **410** in the vehicle when patient support **410** is loaded into the vehicle. Additionally, an arresting device used in a cot fastening system, such as disclosed in U.S. Pat. No. 7,287,794, which is incorporated by reference herein its entirety, can be used to

fasten the patient support in the vehicle. As will be more fully described below, when patient support **410** is fully loaded into the vehicle, the vehicle based power supply will recharge the rechargeable power supply of the patient support **410**. Similarly, when the loading and unloading device (**414**) is in a preselected position in the vehicle, its rechargeable power supply will be recharged by the vehicle based power supply.

(103) To charge the rechargeable power supplies, the vehicle incorporates an induction based power supply system **416**. Although described in reference to an ambulance and an ambulance cot, it should be understood that the present invention has broader application, including to other patient supports, such as beds, infant incubators, or the like, and to other vehicles, including a helicopter. Further as previously noted, the vehicle based power supply may be the vehicle battery or another power supply provided in the vehicle.

(104) Referring to FIGS. **22** and **23**, induction based power supply system **416** includes a conventional DC power supply or source **416a**, such as a battery, which is connected to two power supply circuits **418** and **420** for recharging the rechargeable power supplies on patient support **410** and on the loading and unloading device **414** through wireless power transmission, namely by inductive coupling. As best seen in FIG. **22**, patient support **410** includes a rechargeable power supply or source **422** that is mounted to patient support **410** and, further, a power receiving or recharging circuit **424** that is electrically coupled to rechargeable power supply **422** for recharging power supply **422**. As described below, recharging circuit **424** wirelessly receives power from power supply circuit **418** to thereby recharge supply **422**.

(105) As best understood from FIG. **22**, power supply circuit **418** is coupled to vehicle based power supply **416a** and includes a primary or transmitting coil **418a**, which transmits power wirelessly to a secondary or receiving coil **424a** of recharging circuit **424**. In this manner, when electricity is passed through circuit **418** and the electricity passes through coil **418a**, coil **418a** will generate a magnetic field. The magnetic field in coil **418a** will in turn induce a magnetic field in coil **424a** when coil **424a** is in close proximity to coil **418a**, which will induce current flow in coil **424a** and in turn in circuit **424**, which is coupled to rechargeable power supply **422** to thereby recharge power supply **422**.

(106) In the illustrated embodiment, rechargeable power supply **422** and recharging circuit **424** are provided at the foot end **426** of patient support **410** and, further, such that receiving coil **424a** is aligned with transmitting coil **418a** when the patient support **410** is fully inserted or positioned in vehicle **412** by loading and unloading system **414**. By providing a loading and unloading system **414** that loads the patient support **410** into a vehicle **412**, the location of the patient support in the vehicle can be controlled such that its location when fully inserted is repeatable and, further, done in a manner to allow the transmitting and receiving coils to be closely aligned and/or in registry with each other to ensure the proper physical positioning of the respective coils, which will reduce the power loss in the wireless transfer of power and optimize the inductive coupling efficiency.

(107) Referring to FIG. **23**, as noted above, loading and unloading device **414** includes a rechargeable power supply **428**, such as a battery, and a receiving or recharging circuit **430** that is electrically coupled to rechargeable power supply **428**, which similarly receives power from power supply **416a** through power supply circuit **420**. Receiving circuit **430** also includes a receiving coil **430a**, which receives power from transmitting coil **420a** of power supply circuit **420** when the loading and unloading device is positioned in its fully retracted or inserted position within the vehicle and coil **430a** is aligned with coil **420a**.

(108) Again referring to FIG. **23**, loading and unloading device **414** includes a carriage or trolley **434**, which is mounted on one or more tracks or rails **436**, which are in turn mounted to the deck **438** of vehicle **412**. Carriage **434** is movably mounted to tracks or rails **436** by a pair of guides (not shown). For example, where the tracks or rails are tubular, guides **436** may comprise sleeves, such as described in PCT/US2004/001070 published under WO 2004/064698. In the illustrated embodiment, carriage **434** is configured to engage and releasably couple to the head end of patient

support **410** so that patient support **410** may be guided into vehicle **412** by loading and unloading device **414** either manually or pulled into the vehicle by a driver, noted below.

(109) Mounted to carriage **434** is an arm **440**, which is adapted to lift the head end of the patient support to allow an attendant to guide patient support **410** onto carriage **434** to couple the patient support to carriage **434** so that when carriage **434** is pushed or retracted into the vehicle, patient support **410** will be guided into the vehicle. Arm **440** comprises a generally U-shaped member with two arm portions and a transverse member, with the two arm portions pivotally mounted at their distal or proximate their distal ends to carriage **434**.

(110) As best understood from FIG. **21**, arm **440** is pivotally mounted to carriage **434** by an axle or pin **442**, which extends through the respective ends of the arm portions and carriage **434** to permit arm **440** to move between a generally horizontal position, such as shown in FIG. **21**, and a downwardly angled or lowered position, such as shown in FIG. **21**, so that patient support **410** can be guided onto arm **440**. Pin **442** may be extended through bushings mounted in carriage **434** and held in place by conventional mechanisms, such as retaining rings or cotter pins or the like.

(111) Arm **440** is moved between its generally horizontal position and lowered position by driver **444**, such as a linear actuator, including a hydraulic cylinder, which is mounted at one end in carriage **434** and at its opposed end to arm **440**. When the linear actuator is extended, arm **440** is moved to its generally horizontal orientation, and when the linear actuator is contracted arm **440** moves to its lowered position to receive patient support **410**. Driver **444** is electrically coupled to and powered by rechargeable power supply **428**, which as noted above is recharged when loading and unloading device **414** is fully retracted into the vehicle.

(112) As best seen in FIGS. **22** and **23**, receiving coil **430a** is mounted to the leading end of carriage **434**, while transmitting coil **420a** is located at or near the proximate end of track **436** so that receiving coil **430a** will align with and be in close proximity to coil **420a** when carriage **434** is fully retracted on the tracks into the vehicle. In this manner, when carriage **434** is fully retracted into the vehicle and coil **420a** is energized, its magnetic field will generate a magnetic field in coil **430a** to thereby wirelessly transmit power to recharging circuit **430** and, hence, can recharge rechargeable power supply **428**.

(113) Similarly, patient support **410** includes an electrically powered device **446** that is powered by rechargeable power supply **422**. In the illustrated embodiment, the electrically powered device is a driver, namely an elevation mechanism, for raising the base **448** of patient support **410** relative to the patient support surface **450**, which in a cot is referred to as a litter, so that patient support **410** can be configured in a more compact configuration when being loaded into vehicle **412**.

(114) In the illustrated embodiment, carriage **434** include a releasable latch **452** which is configured to engage the guide wheel support **454** of patient support **410**, which is mounted to the head end of patient support **410**. For example, a suitable latching device is described in U.S. Pat. No. 6,796,757, which is commonly assigned to Stryker Corporation of Kalamazoo, Mich. and is incorporated by reference in its entirety herein. Guide wheel support **454** supports a wheel or bearing **456** that supports the head end of the patient support **410** on the vehicle deck when patient support **410** is inserted into the vehicle, as would be understood by those skilled in the art. Similarly, arm **440** may include a guide wheel **458**, which rides on deck **438** to support arm **440** when arm **440** is in its horizontal orientation. Further, to facilitate manual removal or retraction of the patient support from the vehicle, arm **440** may also include a handle **460** at or proximate its distal end.

(115) Again referring to FIG. **22**, coil **424a** is located beneath patient support surface **450a** of patient support **410** and, as previously noted, at the foot end **426** of patient support **410**. Further, coil **424a** is positioned so that when patient support **410** is fully inserted into the vehicle and carriage **434** is fully retracted in the vehicle along track or tracks **436**, coil **424a** will align and be in registry and/or close proximity to coil **418a**, which is supported adjacent track **436** on deck **438**. In this manner, when the patient support is fully inserted in the vehicle both receiving coils (**424a** and



**430a**) will align and be in registry and/or close proximity to the respective transmitting coils (**418a** and **420a**).

(116) Alternately or in addition, either circuit **420** or **430** and **418** or **424** may include an impedance matching circuit to improve the resonant frequency match between the respective circuits, which will improve transmission and hence efficiency of the power transmission, as known to those skilled in the art. For example, the impedance matching circuit may include feedback loops that check the resonance of the power supply circuit (**418**, **420**) and of the receiving circuit (**424**, **430**) so the impedance of the power supply circuit can be adjusted. The feedback loop(s) may provide a dynamic circuit that seeks resonance between the two circuits. As a result, the power circuit can automatically adjust the frequency of the applied current to the transmitting coil to maintain the frequency resonant with the frequency of the receiving circuit, such as described in EP0700574B1, which is incorporated by reference herein in its entirety.

(117) In addition to power transmission, coil **424a** may be used to wirelessly transmit data from patient support **410** to vehicle **412** through induction. For example, modulated data signals may be transmitted to coil **424a**, which can then wirelessly transmit the data signal to the receiving coil using induction, in this case coil **418a**, which generates a reception signal. The reception signal is then demodulated by a demodulator. The demodulator then may transmit the signal to a processor or storage device, where it can be processed or stored for later use.

(118) For example, power management data may be transmitted from patient support **410** to vehicle **412**. Patient support **410** may include a storage device, for example, for storing data relative to the charging and using of rechargeable power supply **422**. This data may be stored on the power supply or battery or on the charger. Power management data may include, for example, the number of times the battery is charged and the length of use of the battery, which data may be processed for evaluation or stored for later evaluation. Therefore, in this application, the receiving coil at the patient support becomes a transmitting coil for transmitting the data to a receiving coil, for example coil **418a**, which then becomes a receiving coil.

(119) Other data that may be transmitted includes the identification of the patient support or data related to the patient. For example, the patient support may incorporate an RFID tag, which identifies the type of patient support, and an RFID reader may be provided on the loading and unloading device so that the loader will recognize the patient support and, for example, know when to actuate the linear actuator to lift the head end of the patient support and how high, for example. Similarly, the identification of the patient support may be transmitted to the vehicle using data transmission by induction rather than RF transmission in a similar manner noted above.

(120) Patient data that may be transmitted may include patient weight. For example, patient support **410** may incorporate load cells, which are coupled to an onboard processor that determines the weight of the patient based in the signals from the load cells. This data may be displayed at the patient support, for example, by a LCD display or other types of displays, so that the EMS personnel can determine the correct dosage of a medicine or treatment for example. This data similarly can be transmitted from patient support **410** to the storage device on the vehicle, which data can then be stored or processed for later use.

(121) Alternately or in addition, the data may be inductively transmitted to a storage device on a handheld device (e.g. for an EMT or for EMS services) that includes a receiving coil that is in communication with the data storage device in the handheld device.

(122) Further, the data in the storage device in either the vehicle or the handheld device may be transmitted, for example, wirelessly to a hospital storage device, including to a patient database. In addition, the transmission of the data may be made directly between the patient support coil (**424a**) and a hospital receiving coil when the patient support is delivered to the hospital, with the hospital receiving coil in communication with the hospital storage device.

(123) When data transmission is also provided, frequency-shift keying techniques may be used to minimize the disturbance on the power transmission, such as described in EP0700574B1.

(124) In addition or alternately to drivers **444** and **446**, other drivers and/or other electrically power devices may be powered by rechargeable power supplies **422** and **428**. For example, loading and unloading device **414** may incorporate a driver to move carriage relative to the tracks under power to thereby pull or push the patient support relative to the deck. Further, patient support **410** may include a fifth wheel to power the patient support, which may also be powered by rechargeable power supply **422** when patient support **410** is being maneuvered through a hospital or at an accident site or the like. Further, electrically powered accessories mounted at patient support **410** may also be powered by rechargeable power supply **422**. It can be appreciated that the power demand on the rechargeable power supply **422** can be significant; hence, the inductive recharging system of the present invention may significantly prolong the life of the power supply **422**, as well as, power supply **428**. Moreover, by eliminating the electrical connections, no direct physical contact between the two electrical circuits occurs, which reduces the risk of electrical shock to the patient or the caregiver. In addition, with electrical connectors, repetitive coupling and decoupling can cause wear and tear on the connections. Further, electrical connections require greater precision in the alignment between the connectors.

(125) As noted above, patient support **410** may be secured in the vehicle using other fastening systems. Referring to FIGS. **24-29**, another embodiment of a patient support or cot fastening system is illustrated, which comprises a loading and unloading device **514** that is of similar construction to loading and unloading device **414** of the first embodiment and may incorporate a rechargeable power supply and recharging circuit described in reference to the first embodiment. For further details of the rechargeable power supply and recharging circuit reference is therefore made to the previous embodiment.

(126) Device **514** includes a carriage or trolley **534** that is mounted on track **536**, which is in turn mounted to the deck **538** of a vehicle. In the illustrated embodiment, track **536** comprises a rectangular tubular track with opposed guide surfaces **536a** for guiding carriage **534**. Carriage **534** is movably mounted on track **536** for linear movement along track **536** by an intermediate elongate member **535**, such as an inverted, generally channel-shaped member. Intermediate member **535** includes a plurality of bearing assemblies **535a**, for example a plurality of vertically oriented rollers, that engage sides **536a** of track **536** and guide member **535**, as well as carriage **534**, along track **536**. The rollers or bearings are mounted in member **135** between upper and lower inwardly extending flanges by fasteners **535b**. Intermediate elongate member **535** also includes a second plurality of bearings **535c**, such as wheels or rollers, mounted in the channel-shaped member for engaging deck **538** to thereby provide vertical support to member **535** and carriage **534** as they moves along track **536**.

(127) Carriage **534** similarly comprises an inverted, generally channel-shaped member and also includes a plurality of bearing assemblies **534a**, which are similarly secured between inwardly extending flanges by fasteners **534b** and that engage opposed sides **535d** of member **535** so that carriage **534** is movably mounted to member **135**. In this manner, carriage **534** and member **535** form a nested rail arrangement in which member **535** can be extended from track **536**, and carriage **534** can be extended from member **535** beyond the end of track **536** to extend carriage **534** further from the vehicle, for example, than the first embodiment.

(128) Similar to device **414**, device **514** includes a pair of pivotal arms **540a** and **540b**, which are pivotally mounted to carriage **534** and which are moved between a raised or inclined position, shown for example in FIG. **27**, and a lowered position shown in FIG. **24** when carriage **534** is fully extended from the vehicle for loading or unloading patient support **410** into or from the vehicle. In the illustrated embodiment, arms **540a** and **540b** are commonly mounted to or formed on a base **540c**, which is pivotally mounted to carriage **534** by a pair of hinges **542**. Base **540c** optionally includes one or more bearings or rollers **540d**, which support base **540a** on deck **538** when carriage **534** is retracted into the vehicle. To facilitate handling of carriage **534**, arms **540a** and **540b** also optionally include handles **541** similar to the previous embodiment.

(129) Arms **540a** and **540b** are pivoted by at least one actuator housed in carriage **534**, which is mounted on one end to base **540c** and mounted at its other end to carriage **534**. Thus when the actuator is contacted, arms **540a** and **540b** will be lowered relative to carriage **534**, and when the actuator is extended the arms will be raised back to their raised or inclined position illustrated in FIG. 27. Thus, loading and unloading device **514** operates in a similar manner as device **414** but has an extended range of motion.

(130) As best seen in FIG. 28, at the proximate terminal end **536b** of track **536**, device **514** includes a stop assembly **550**. Stop assembly **550** is secured to deck **538** at the terminal end of track **536** and extends transversely relative to track **536** so that when carriage **534** is fully retracted into the vehicle, carriage **534** will be in close proximity if not abut stop assembly **550**. Optionally, stop assembly **550** may comprise a housing **550a** formed from a member having a similar cross-section to carriage **534**, e.g. an inverted channel shaped member, so that when carriage **534** is fully inserted into the vehicle along track **536** the two members forming the carriage and the stop assembly will abut each other and have a shared geometry, which facilitates the mounting of the respective coils for the inductive power supply system. In this manner, stop assembly **550** may house the transmitting circuit described in reference to the previous embodiment in housing **550a**. In addition, stop assembly **550** optionally includes a projecting stop member **552**, which is aligned with member **535** so that member **535** will be spaced from stop assembly **550** when fully retracted along track **536**, though carriage **534** will be in close proximity if not abut housing **550a**. In addition, stop assembly **550** also may include a locking mechanism **554** that includes a spring biased latch **554a** with a switch, which is located such that carriage **534** will initially compress the latch and close the switch, when carriage **534** is retracted and moved toward the stop assembly housing **550a**, but once fully retracted will allow the latch to return to its pre-compressed position and engage carriage **534**. Thus, when carriage **534** and arms **540** are in their fully retracted position along track **536**, latch **554a** will engage carriage **534** to thereby locking the carriage **534** and arms **540** in their fully retracted position. The switch may be used to trigger the recharging of the rechargeable power supply located in carriage **534** and/or provide a signal of when the loading device is in its retracted position in the vehicle.

(131) Similar to device **414**, the rechargeable power supply located in carriage **534** may be used to power the actuator that raises or lowers arms **540a** and **540b**. In addition, carriage **534** may include a driver to move carriage **534** relative to member **535** and/or relative to track **536**, which may also be powered by the carriage's on board rechargeable power supply.

(132) To secure the patient support **410** to loading and unloading device **514**, loading and unloading device **514** similarly includes at least one latch **560** for fastening the patient support **410** to carriage **534**. Referring to FIG. 27-29, latches **560** are mounted to the opposed sides of carriage **534**, which are adapted to releasably engage the head end wheel or bearing supports, described in reference to the first embodiment, which are mounted to the head end of the patient support **410** to facilitate loading of the patient support into the vehicle.

(133) Referring to FIG. 30, another embodiment of the cot fastening system **614** for securing a patient support **610** is illustrated. Cot fastening system **614** comprises an “antler” system with a center yoke **678** and a forward yoke **680**. Both yokes **678**, **680** are mounted to the ambulance cargo area floor, with a centerline of the antler system **614** aligned in the fore-aft direction of the ambulance.

(134) The center yoke **678** is formed from two rods **682**, **683** arranged as mirror images about the centerline of the antler system **676**. Each rod **682**, **683** includes a longitudinal segment **684**, **685** and an outwardly divergent segment **686**, **687**, each outwardly divergent segment **686**, **687** rising to a rearwardly directed hook or “ear” **688**, **689**.

(135) The forward yoke **680** includes a central segment **690** secured to the ambulance cargo floor and two outwardly divergent arms **691**, **692**. The arms each terminate in an “ear” **693**, **694** that is joined with a respective ear **688**, **689** of the center yoke **678**.

(136) Positioned at central segment **690** is a transmitting circuit and transmitting coil **618a**, which are electrically coupled to a power supply, such as a battery on the vehicle, for wirelessly transmitting power to a rechargeable power supply on support **610**. Similar to support **410**, support **610** optionally includes a rechargeable power supply and a recharging circuit that is electrically coupled to the rechargeable power supply. In the illustrated embodiment, the rechargeable power supply and recharging circuit are located at the head end of the patient support **610** so that when patient support **610** is fully loaded into the vehicle, the recharging circuit receiving coil will be aligned with central segment **690** and further with transmitting coil **618a** of the transmitting circuit.

(137) As patient support **610** (only the retractable head section **697** of support **610** is shown) is rolled into the vehicle head end first, as shown by the arrow in FIG. **30**, safety bar **618** of support **610** contacts the center yoke **678**. As the support **610** is rolled further, the center yoke **678** forces the safety bar **618** rearwardly until the safety bar **618** rides on top of the longitudinal segments **684**, **685** of the rods **682**, **683** of the center yoke **678**. Again referring to FIG. **30**, the latch disabler (illustrated and described more fully in publication US 2006/0075558, which is incorporated by reference herein in its entirety) on support **610** is activated prior to stop **672** reaching the shaft (numbered 266 in US 2006/0075558). This enables use of the support **610** with an antler system having a lower profile, while still activating the latch disabler. With the safety bar **618** in the rotated position, the latch disabler is activated, thereby locking the retractable head section **697** of support **610** in the extended position. The latch disabler will remain activated until the support **610** is removed from antler system **676**. As the patient support **610** is pushed further forward, the fixed wheels **616** roll between the ears **688**, **689** and **693**, **694** of the center and forward yokes **678**, **680** and into the antler system **676**.

(138) In this manner, when support **610** is fully retracted onto system **614** and preferably locked in its locked position, the receiving coil of the recharging circuit for the rechargeable power supply of support **610** is positioned in close proximity to transmitting coil **618a** of antler system **614** so that the rechargeable power supply of support **610** can be charged using wireless power transmission from the antler system. For further details of antler system **614** and support **610** reference is made to US 2006/0075558 referenced above.

(139) Accordingly, the aforementioned embodiments provide a power system that eliminates the need for direct electrical connectors and reduces the concern for battery management, while enhancing safety. Further, the loading and unloading device of the present invention may provide a greater range of motion and extension from the vehicle than heretofore known to further facilitate the loading and unloading of the patient support from a vehicle equipped with the loading and unloading device.

(140) C. More Vehicular Patient Support Apparatuses

(141) FIGS. **31-38D** illustrate additional embodiments of a patient support apparatus and a loading/unloading system for loading and unloading the patient support apparatus into, and out of, a vehicle. Any of the components and/or features of the patient support apparatuses of FIGS. **1-30** may be incorporated into, either in whole or in part, any of the vehicular patient support apparatuses and/or loading/unloading systems described below with respect to FIGS. **31-38D**. Some components of the patient support apparatuses of FIGS. **31-38D** are described in more detail in U.S. patent application Ser. No. 11/769,959, which is incorporated by reference herein. The reference numbers in FIGS. **31-38D** correspond to the reference numbers in the '959 patent application but have been increased by 700. Thus, for example, the reference number **10** in the '959 patent application corresponds to reference number **710** herein.

(142) Referring to FIG. **31**, the numeral **710** generally designates another embodiment of an ambulance cot and loading and unloading system incorporating one or more aspects of the present invention. Additional details of the patient support apparatus and cot loading/unloading system can be found in U.S. patent application Ser. No. 12/886,987 filed Sep. 21, 2010 and entitled AMBULANCE COT AND LOADING AND UNLOADING SYSTEM, by applicants Clifford

Lambarth et al., the complete disclosure of which is hereby incorporated herein by reference.

(143) System **710** includes an ambulance cot **712** and a cot loading and unloading apparatus **714**, which is configured for mounting in the cargo area **716** of an ambulance **718**. Cot loading and unloading apparatus **714** is configured to assist in the loading or unloading of a cot into or out of ambulance **718** by providing cantilevered support to the cot either before the cot is loaded into the ambulance so that as soon as the cot is engaged and lifted by the loading and unloading apparatus the collapsible legs or base of the cot can be folded and the cot loaded into the ambulance or when the cot is being unloaded. By cantilevered support it is meant that an attendant need not provide any significant vertical support to the cot and instead need only simply guide and push or pull the cot into or out of the ambulance once it is supported by the loading and unloading apparatus.

(144) Cot loading and unloading apparatus **714** includes a base **720**, which is mounted in the cargo area of the ambulance, and a transfer track **722**, which is mounted on the base. Cot loading and unloading apparatus **714** also includes a trolley **724**, which is mounted on the transfer track for movement therewith along the base. The track **722** and trolley **724** are configured to provide a nested rail arrangement to provide greater extension of the trolley from the emergency vehicle. Additionally, the nested rail arrangement is provided with at least one latch and more optionally, a series of latches that couple the track to the base and allow the trolley **724** to move along the track and thereafter release the track so it too can move with the trolley relative to the base to thereby fully extend the trolley from the vehicle (FIG. **31**). As best seen in FIG. **31**, in this configuration arms **734a** and **734b** pivot about a pivot axis P that is outside the ambulance, which allows arms **734a** and **734b** to have a greater range of motion. As previously noted, once the cot is loaded onto trolley and the arms lift the cot, the collapsible base of cot **712** is collapsed and trolley **724** along with cot **712** can be pushed along the base with head end wheels **786a** straddling base **720**.

(145) Base **720** is formed from an extrusion, such as aluminum extrusion, which is anchored to the cargo area by a sub-anchor assembly. Track **722** is also formed from an extrusion and straddles base **720** and, further, is guided on base **720** by bearings **732**, such as rollers or wheels, which are mounted to base **720** and which ride along inner rails **728**.

(146) The underside of trolley **724** forms an inverted channel, which straddles track **722** and is mounted to track **722** by a plurality of bearings **804**, such as wheels or rollers, that ride along outer rails **720** until bearings **804** reach end caps **728b**, which form the stops at the end of track **722**. When trolley **724** reaches the end of track **722**, trolley **724** is adapted to disengage the latch that anchors the position of track **722** along base **720** so that thereafter track **722** rides along base **720** along with trolley **724** to an extended position as shown in FIG. **32** and FIG. **31**. Thus, when trolley **724** is fully extended along track **722** and track **722** is fully extended along base **720**, trolley **724** extends from track **722** beyond base **720** (see FIG. **31**). In this manner, trolley **724** can be extended from the ambulance cargo area and further extended from the ambulance.

(147) To engage cot **712**, trolley **724** includes an arm assembly **734** with a pair of cantilevered of arms **734a**, **734b** and a trolley frame **736** to which arm assembly **734** is mounted for pivotal movement by a transverse member **738**. Arms **734a**, **734b** are pivoted between a lowered, pre-engaged position (FIG. **31**), a raised cot engaged position, and non-deployed or stowed position (FIG. **33**) by a drive mechanism **740**. Further, as will be more fully described below, when trolley **724** is in its stowed configuration with arms **734a**, **734b** in a generally horizontal arrangement, arm assembly **734** is adapted to releasably engage track **722** so that trolley **724** is releasably anchored to track **722**. Further, as will be more fully described below, when an attendant raises arms **734a**, **734b** the attendant can release this engagement and move trolley **724** along track **722** to position trolley **724** anywhere along track **722**. Thus, an attendant may position trolley **724** toward the rear of the cargo area just inside the ambulance doors for quick deployment, thus eliminating the need for the attendant to climb into the cargo area to retrieve the trolley. To facilitate movement of trolley **724** and provide support to the arm when the arms are moved along the cargo area deck (when the arms are in the generally horizontal arrangement), arms **734a**, **734b** optionally include rollers **734c** for

rolling on the cargo deck outwardly of track **722** and base **720**.

(148) Drive mechanism **740** is configured to raise arms **734a**, **734b** at a first speed when the arms are deployed, but not loaded by an applied force, for example when not loaded with a cot, but is configured to raise the arms (**734a**, **734b**) when in their deployed position at another, slower speed or speeds when the arms are loaded with an applied load, for example when engaged with and lifting a cot. For example, the slower speed at which the arms are raised may be variable or may have two or more discrete speeds for specific ranges of motion. Further, drive mechanism **740** may be configured to lower the arms **734a**, **734b** at a first speed when the arms are not subject to an applied load, e.g. not lifting a cot, but to lower the arms at another slower speed or speeds if the arms are subject to an applied load, e.g. lifting a cot. Alternately, the driver mechanism may be configured to raise or lower the arms at a slower speed only when the arms are loaded with a weight that exceeds the weight of a cot, for example, when a cot is supporting a patient. Optionally, the arms could be moved (raised or lowered) at one speed when fully unloaded, another slower speed when loaded with a cot, and yet another even slower speed or speeds when the arms are moving (lifting or lowering) a cot that is supporting a patient.

(149) Drive mechanism **740** is mounted to trolley frame **736** and, in the illustrated embodiment, comprises a hydraulic drive mechanism, namely a hydraulic cylinder **742** and a hydraulic power unit **744**. Rod **742a** of cylinder **742** includes a bushing **742b** on its rod end and also a switch **742c**, which is used by control system **900** to determine the load on the arms. Bushing **742b** is connected to outer side **738a** of transverse member **738** by a pin **738c**, such as a clevis pin, with the other end of cylinder **742** mounted to frame **736** by a pivot **742d**, which in turn is secured to frame **736** by a fastener **742e**. A return spring may also be provided that is mounted on one end to the frame and at another end to the arm assembly, which provides a counter balancing force to the cylinder to reduce the load on the cylinder when the hydraulic mechanism is actuated to raise arms **734a** and **734b** and also slow the lowering of arms **734a**, **734b** when the release button described below is actuated.

(150) As previously noted, trolley **724** is adapted to engage cot **712**. Trolley **724** includes a pair of latches **770** for engaging cot **712**. Frame **736** supports two latches **770**, one at each side of frame **736**. Latches **770** are mechanically actuated and released, but may also be electrically released. Latches **770** each include a latch plate **772a** and latch arm **772b**. Latch plate **772a** and latch arm **772b** are mounted in a bracket **74** that forms a housing for mounting latch **770** to frame **736**. Latch arm **772b** is pivotally mounted in bracket **74** for movement between an unlocked position in which arm **772b** is pivoted through an open side of the bracket for engagement by the cot (or for release of the engagement of the cot) and a locked position. Latch arm **772b** is biased in its unlocked position by a spring (not shown), which is configured with an over center arrangement so that the spring also biases the latch arm in its locked position after latch arm **772b** is moved out of its locked position. To release latch plate **772b** from its locked position, latch arm **772b** includes a pin **776** for actuation by a solenoid **780**, which is controlled by control system **900**, more fully described below.

(151) Solenoid **780** is mounted to frame **736** by a bracket **782** and includes a plunger **778** that is coupled to a bracket that engages pin **776**. Thus, when solenoid **780** is activated, plunger **778** will lower and the bracket will pull on pin **776** to allow the biasing force of the spring to move latch arm **772b** to its unlocked position. As will be more fully disclosed below, latch **770** may also be manually released by manual release assembly **880**.

(152) When cot **712** is aligned with the rear opening of the ambulance and trolley **724** is fully extended along base **720**, and arms **734a**, **734b** are lowered, cot **712** can then be pushed toward the ambulance so that arms **734a**, **734b** extend into the cot beneath the head end wheeled frame **786** of cot **712**. Cot **712** is then pushed and guided by guide surfaces formed on housing **788** of trolley **724** and into a pair of recesses **788a** also formed in housing **788**, which are configured to guide wheels **786a** into engagement with the latches (**770**) on trolley **724**. Each wheel **786a** includes a laterally extending pin **790** for engagement by latches **770**.

(153) Base **720** is anchored to the cargo deck of the ambulance by a sub-anchor assembly **792**. Anchor assembly **792** includes an anchor member or plate **792a**, which is fastened in or on the deck by a plurality of attachment brackets **794**. Plate **792a** is generally channel-shaped whose channel is covered by cap plate **796** and ends are covered by end caps **798**. Plate **792a** optionally provides through holes to allow cabling to extend from the loading and unloading apparatus to the vehicle power supply system. As will be more fully described below, system **710** may incorporate an inductive charging system for charging batteries on the trolley and the cot. Anchor plate **792a** may also provide anchorage for an optional safety hook **802** that can be engaged, for example, by a frame member of cot **712** after unloading the cot from or before loading the cot onto loading and unloading apparatus.

(154) To anchor trolley **724** and the cot **712** during transport, base **720** supports a latch mechanism **805** for engaging trolley **724**. Referring to FIGS. **32-33**, track **722** has a forked end **722b**, which when fully retracted along base **720** allows track **722** to straddle latch mechanism **805**, which helps reduce the overall contracted length of loading and unloading apparatus while providing full extension of trolley **724** along base **720**. Further, this allows latch **805** to engage trolley **724** when trolley **724** is fully retracted over track **722**.

(155) Latch mechanism **805** includes a pawl **806**, which is pivotally mounted in housing **808** by a pivot pin **806a** and biased in an extended or locking position by an actuator **810**. Pawl **806** is also coupled to a manual release plate **812** via a pin connection. Plate **812** supports a button **812a** that extends through a mounting bezel **812b** on housing **808** so that it is accessible to an attendant in the front of the ambulance cargo area. Plate **812** is also coupled to a pair of springs **814** to thereby return button **812a** to its non-release position after the pressure on the button is removed. Optionally, plate **812** is also coupled to a release mechanism **815** (FIG. **34D**) provided at the other end of base **720**, described more fully in reference to FIG. **34D** below.

(156) Actuator **810** includes a plunger **816** that is biased by a spring **818** to apply a downward force on a pivot actuator **820**, which is also pivotally mounted in housing **808** by a pivot pin **820a** and which is coupled to pawl **806** by a link **820b** to thereby urge pawl in its extended position. To engage latch **805**, trolley **724** includes a stop ramp **26a**, which is mounted to the underside of frame **726** in top plate **800c** of rail portion **800** by a pair of fasteners **724c**. In this manner, when trolley **724** is pushed along track **722** toward the front cargo area of the ambulance, stop ramp **724b** will ride on the ramped surface **806b** of pawl **806**, with the weight of the trolley then depressing pawl **806** so that it pivots about pin **806a** against the biasing force plunger **810**. Once block **724b** has moved past the end of the ramped surface **806a** of pawl **806**, plunger **810** will return pawl **806** to its extended locked position behind ramp **724b** and thereby lock trolley **724** as well as track **722** in their full retracted positions along base **720**. Also to provide lateral support at latching mechanism **805**, a pair of retaining plates **805a** are mounted to housing **808** adjacent either side of pawl **806**.

(157) In addition, to further secure cot **712** when fully loaded, the foot end of cot **712** includes a foot end fastener **830** (FIG. **36**) for engaging a fastener **832** provided on track **722**. Fastener **832** (shown inverted) includes a guide **834** with a V-shaped recess **836**, which is mounted in track **722**. Pivotally mounted in guide **834** by a pin **838a** is a hook **838**, which is biased by a pair of springs **840** in an extended position in recess **836** for engaging fastener **830** when the foot end of cot **712** is aligned over fastener **832**. Also mounted to hook **838** is a release plate **838b**, which is coupled to release mechanism **815** which when pulled moves hook **838** to a recessed position for disengaging hook **838** from fastener **830**. Optionally, an indicator plate **838c** may be provided that is also mounted about pin **838a** and which pivots with pin **838a** and extends through a slotted opening in hook **838**, which indicates the status of the hook (i.e. engaged or not engaged).

(158) Referring to FIG. **36**, fastener **830** is mounted to the foot end of cot **712** by a frame **842** and a bracket **846**. Fastener **830** is mounted between a pair of wheels **844**, which are also mounted to frame **842** by bracket **846**, and positioned for engaging the floor of the cargo area when cot **712** is being loaded onto or unloaded from the loading and unloading apparatus. Wheels **814**, therefore,

provide further support and stability to the cot, when the cot is loaded into the ambulance. Fastener **830** includes a pair of pawl hooks **848**, which are pivotally mounted in a housing **850** (which is mounted to frame **842**) by a pair of pins **852** and further biased outwardly by a coil spring **854** so that their distal ends project beneath housing **850** for engagement with fastener **832**. Once so engaged, fastener **830** will restrain the cot relative the transfer track **722** from vertical, lateral (side to side), and longitudinal movement.

(159) As noted above, to release trolley **724** from its full retraced and locked position at latch mechanism **805**, an attendant need only push button **812a**, which causes pawl **806** to pivot about pin **806a** into its lowered or depressed position in housing **808**. Alternately, latch mechanism **805** may be released by release mechanism **815**. Referring to FIG. **34D**, release mechanism **815** includes a trigger **815a**, which is rotatably mounted in a housing **815b** mounted to the end of base **720**. Trigger **815a** is coupled to an actuation plate **815c**, which is positioned and aligned to actuate a pair of drive rods **815d** and **815e** via drive blocks **815f**. Drive rod **815e** is coupled to actuator **820** of latch mechanism **805** so that when trigger **815** is rotated its rotational axis, actuator plate **815c** will urge drive rod **815e** to pivot actuator **820** about its respective pivot axis to thereby pivot pawl **806** about its respective pivot pin and thereby allow trolley **724** to be disengaged from latch mechanism **805**. In a similar manner, drive rod **815d** is coupled to release plate **838b** of fastener **832** so that when trigger **815a** is rotated about its pivot pin, hook **830** will be moved to its recessed position for disengaging hook **838** from fastener **830**. Optionally, trigger **815a** may provide two actuation positions, one for releasing fastener **832** and a second position for releasing both fasteners **832** and latch **805**.

(160) Control system **900** may include an inductive charging system, such as described in copending application entitled POWERED PATIENT SUPPORT AND FASTENING SYSTEM WITH INDUCTIVE BASED POWER SYSTEM, Ser. No. 60/949,005, filed Jul. 11, 2007, which is hereby incorporated by reference in its entirety.

(161) In the illustrated embodiment, control system **900** includes two control systems, a cot-based control system **902** and a loading and unloading apparatus-based control, for example, a trolley-based control system **904**. Each control system **902**, **904** includes a control board **908** and **910** (with a microprocessor and memory storage unit), which are in communication with user input devices **902a** and **204a**, which are provided at cot **712** and trolley **724**, respectively. User input devices **902a** and **904a** each include user actuatable buttons or switches **904b** (only user input device **904a** is shown in detail) to allow a user to input signals for raising or lowering arms **734a**, **734b**. Further, user input device **904a** also include a manual dump button **904c**, which when pressed presses against a linkage **904d** that couples to the manifold to release fluid from the cylinder into a reservoir so that the arms can be quickly lowered.

(162) Control system **902** and **904** also each include a communication board **912**, **914** with wireless transmitters and/or receivers, such as RF devices, inductive devices, acoustic device, optical devices, or infrared devices, between the cot-based control system **902** and trolley-based control system **904** so that cot-based control system **902** can control the devices at loading and unloading apparatus. Communication may be one-way or two-way communication.

(163) To determine the height, angles, speeds, stop points/conditions, and acceleration, system **710** also includes an arm angle position sensor **916**, which is mounted to frame **736** by a mounting bracket **916a** and is coupled to arm assembly **734** by a link **916b**, which is used to determine the angular position of the arms. Its values are referenced against preset registers to determine speeds, stop points/conditions, and acceleration. Control system **900** may also include a sensor **918** to detect when trolley **724** is latched at latching mechanism **805** and to provide feedback to control system **900** when trolley **724** is latched. Further, control system **900** may include one or more USB port devices to allow information, data, programming upgrades, or programming to be uploaded to the respective cot-based control system **902** and/or trolley-based control system **904**. In addition, system **900** may incorporate a plurality of indicators **924**, such as LEDs, to provide status



indication, such as low battery, a power light (to indicate that the system is powered), and other operational indicators.

(164) As noted above, control system **900** may incorporate an inductive charging system for charging the battery **920** on the loading and unloading apparatus and/the battery **922** on the cot. Primary and secondary coils may be electrically coupled to the respective batteries and located on the cot, on the trolley, and in the base to allow recharging of the respective batteries through induction. Further, the charge regulation circuitry for the trolley battery may reside on the trolley-based control board **910**, while the charge regulation circuitry for the cot battery may reside on the cot-based control board **908**.

(165) For example, latch mechanism **805** may house a primary coil **930**, which couples to the electrical system of the vehicle through the sub-anchor assembly **792**, and trolley **724** may house a secondary coil **932**, which is in communication with trolley-based control board **910**, so that when aligned with coil **930** in the latch mechanism **806** (when trolley is moved to its fully retracted position), electricity can be generated by inductive coupling to recharge the trolley battery (which is housed in trolley) from the vehicle's electrical system. Similarly, base **720** may include another primary coil **934** adjacent fastener **832**, which is also coupled to the vehicle electrical system, for example through sub-anchor assembly **792**, and cot **712** may include a coil **936** (FIG. 36), which is electrically coupled to the cot battery through cot-based control board **908** so that the cot battery can also be recharged using the vehicle electrical system. Further, to facilitate close positioning of coil may be enhanced by mounting coil **934** in a spring biased housing **934a** (FIG. 34A) so that when track **722** is moved along base **720**, coil **934** will not interfere with the movement of track **722**.

(166) Alternately, the system of the present invention may incorporate electrical contacts to provide direct electrical coupling between the trolley and the base, as described in the reference patent, and further may provided a cabling between the cot and trolley based control systems rather than the wireless connection described herein.

(167) The above description is that of current embodiments of the invention. Various alterations and changes can be made without departing from the spirit and broader aspects of the invention as defined in the appended claims, which are to be interpreted in accordance with the principles of patent law including the doctrine of equivalents. This disclosure is presented for illustrative purposes and should not be interpreted as an exhaustive description of all embodiments of the invention or to limit the scope of the claims to the specific elements illustrated or described in connection with these embodiments. For example, and without limitation, any individual element(s) of the described invention may be replaced by alternative elements that provide substantially similar functionality or otherwise provide adequate operation. This includes, for example, presently known alternative elements, such as those that might be currently known to one skilled in the art, and alternative elements that may be developed in the future, such as those that one skilled in the art might, upon development, recognize as an alternative. Further, the disclosed embodiments include a plurality of features that are described in concert and that might cooperatively provide a collection of benefits. The present invention is not limited to only those embodiments that include all of these features or that provide all of the stated benefits, except to the extent otherwise expressly set forth in the issued claims. Any reference to claim elements in the singular, for example, using the articles “a,” “an,” “the” or “said,” is not to be construed as limiting the element to the singular.

## Claims

1. A patient support apparatus comprising: a patient support deck for supporting a patient thereon; a wireless power receiver operable to inductively couple and receive electrical energy from a wireless power transmitter when the wireless power transmitter is transmitting power wirelessly in

proximity to the wireless power receiver; and an electrically powered device or subsystem operably coupled to the wireless power receiver, the electrically powered device or subsystem configured to receive power from the wireless power receiver based on the electrical energy received by the wireless power receiver from the wireless power transmitter.

2. The patient support apparatus according to claim 1, comprising an impedance matching circuit to improve a resonant frequency match between the wireless power receiver and the wireless power transmitter.

3. The patient support apparatus according to claim 1, wherein the wireless power receiver includes a wireless power receiving coil.

4. The patient support apparatus according to claim 1, in combination with a vehicle, the wireless power transmitter mounted in the vehicle.

5. The patient support apparatus according to claim 4, wherein the patient support apparatus includes an emergency cot, and the emergency cot includes the patient support deck and a base supporting the patient support deck, and the electrically powered device includes an elevation mechanism for moving one of the patient support deck and the base relative to the other of the patient support deck and the base.

6. The patient support apparatus according to claim 5, in combination with a loading and unloading apparatus mounted in the vehicle, the wireless power transmitter mounted and located to align with the wireless power receiver of the emergency cot when the emergency cot is loaded onto and fully retracted into the vehicle by the loading and unloading apparatus.

7. The patient support apparatus according to claim 1, wherein the patient support apparatus includes a head end and a foot end, and wherein the wireless power receiver is mounted at or adjacent the foot end of the patient support apparatus.

8. The patient support apparatus according to claim 1, wherein the patient support apparatus includes a head end and a foot end, and wherein the wireless power receiver is mounted at or adjacent the head end of the patient support apparatus.

9. A patient support system for a system component comprising: a power supply circuit; a wireless power transmitter operatively coupled to the power supply circuit, the wireless power transmitter configured for inductively coupling and transferring electrical energy to a wireless power receiver of the system component when the wireless power receiver is in proximity to the wireless power transmitter; and an alignment structure operable to align the wireless power transmitter with the wireless power receiver of the system component.

10. The patient support system of claim 9 wherein the alignment structure is an engagement structure operable to engage the system component.

11. The patient support system of claim 10 wherein the engagement structure is operable to facilitate maintaining a position of the wireless power receiver of the system component in proximity to the wireless power transmitter.

12. The patient support system according to claim 9, wherein the power supply circuit includes an impedance matching circuit.

13. The patient support system according to claim 12, wherein the impedance matching circuit is configured to affect a frequency of applied current to the wireless power transmitter to adjust a frequency of the wireless power transmitter.

14. The patient support system of claim 9 wherein the alignment structure includes an arm assembly configured to mount relative to an emergency vehicle, the arm assembly configured to secure the system component in the emergency vehicle.

15. The patient support system according to claim 14, wherein the arm assembly includes a movable arm, and the patient support system includes an electrically powered device configured to move the movable arm.

16. The patient support system according to claim 14, wherein the arm assembly includes a pair of stationary arms configured to secure the system component in the emergency vehicle.

17. The patient support system according to claim 9, comprising a track, the alignment structure mounted for movement along the track between an extended loading or unloading position to engage or disengage from the system component and a fully retracted position along the track.
  18. The patient support system according to claim 9, comprising a second power supply circuit with a second wireless power receiver to inductively couple to and transfer electrical energy from a second wireless power transmitter when the second wireless power receiver is in proximity to the second wireless power transmitter.
  19. The patient support system according to claim 18, wherein the second wireless power receiver is mounted relative to and moves with the alignment structure.
  20. The patient support system according to claim 19, in combination with a vehicle, the vehicle including the second wireless power transmitter operable to inductively transfer power to the second wireless power receiver when aligned with the second wireless power transmitter.
  21. The patient support system according to claim 9, wherein the system component is a loading and unloading device or a patient support apparatus.
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