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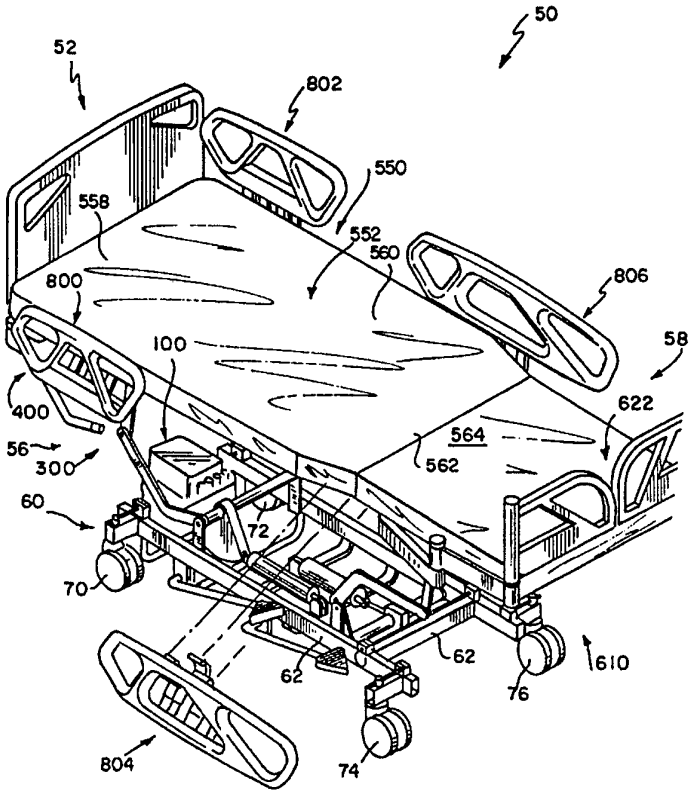
(54) Title: COMMUNICATION NETWORK FOR A HOSPITAL BED

(57) Abstract

A bed (50) includes a base frame (62), a deck (400) coupled to the base frame (62) for supporting a body, a peer-to-peer communication network having a plurality of connection points, and a plurality of modules (1014, 1016, 1018, 1020, 1022, 1024, 1026, 1028, 1030). Each module (1014, 1016, 1018, 1020, 1022, 1024, 1026, 1028, 1030) is electrically coupled to a selected connection point of the peer-to-peer communication network. Each module (1014, 1016, 1018, 1020, 1022, 1024, 1026, 1028, 1030) is configured to perform a dedicated function during operation of the bed (50), and each module (1014, 1016, 1018, 1020, 1022, 1024, 1026, 1028, 1030) is configured to communicate over the peer-to-peer communication network with selected other modules (1014, 1016, 1018, 1020, 1022, 1024, 1026, 1028, 1030).



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COMMUNICATION NETWORK FOR A HOSPITAL BED

Background and Summary of the Invention

The present invention relates to a bed, and particularly to a chair bed that can be manipulated to achieve both a conventional bed position having a horizontal sleeping surface upon which a person lies in a supine position and a sitting or chair position having the feet of the person on or adjacent to the floor and the head and back of the person supported above a seat formed by the chair bed. More particularly, the present invention relates to an electronic control system and communication network for a hospital bed or a patient-care bed.

The electronic system architecture for the hospital bed of the present invention includes a plurality of electronically controlled modules located on the bed which are interconnected in a peer-to-peer configuration. This peer-to-peer communication network configuration enables any of the plurality of modules to communicate directly with another module in the network without the need for a master controller. In the preferred embodiment, information flow between the electronic modules is primarily accomplished through the use of a twisted pair network channel, although other physical protocols would be acceptable.

One feature of the control system of the present invention is improved upgradeability. The peer-to-peer network configuration of the electronic control modules of the present invention facilitates adding or removing modules from the bed. In conventional bed control systems which use a master controller, the master controller must be initially designed or subsequently redesigned to accommodate additional modules. Since no master controller is required in the peer-to-peer network configuration, the electronic control system of the present invention does not

have to be redesigned or reprogrammed each time a module is added or removed from the bed.

An open product architecture for the communication control network and air controls provides substantial flexibility for future additions of new modules. A graphic caregiver interface control module is provided for controlling the operation of various modules of the hospital bed. This control module is coupled to the peer-to-peer communication network. The control module includes a user input control panel and a display. The control module is programmed to recognize when a new module is added to the network automatically and to permit control of the new module from the user input control panel. The control module also displays specific control options for the added new module on the display automatically. Therefore, this new module recognition and control apparatus eliminates the need for separate controls on each individual module.

The network of the present invention also includes a bed status information charting feature. The network allows all data from each of the modules coupled to the network to be available at any time to the other modules. An optional module allows the network to supply information to a remote location through a data link. This information includes information from any of the modules communicating on the network. The peer-to-peer communication network of the present invention transmits electrical signals representing bed status variables that indicate the current position, status, and configuration of the bed. These variables include bed articulation angles, brakes, bed exit, scale, surface therapy attributes, as well as other variables. By detecting and storing changes in these bed status variables in the memory of a module or by transmitting these variables via the data link to a remote location, the present invention permits automatic

charting of the bed status variables. Therefore, the hospital information system can monitor and record changes in the bed status variables continuously during the patient's stay for billing, legal, insurance, clinical/care plan studies, etc. The caregiver can also routinely check a nurse call bed status at a remote nurse master station rather than making bed check rounds. A history of the bed status for a particular patient can be displayed on the graphical user interface module, downloaded to a data file, and/or routed via the data link to a remote location.

The peer-to-peer communication network of the present invention is a distributed network. This distributed design allows for peer-to-peer communications between any of the nodes or modules connected to the network. Failure of a single module does not cause failure or impairment of the entire peer-to-peer communication network.

The peer-to-peer communication network of the present invention includes embedded self diagnostic capability. The network is capable of internally diagnosing hardware and software failures and recommending a corrective action. A signal for this corrective action can be supplied to a troubleshooting screen on the graphical user interface module, downloaded to a data file, and/or transmitted via a data link to a remote location.

Alternately, a service indicator can be lit to indicate the need for servicing of a specific system failure. Remote troubleshooting or diagnostics is also possible through a modem connected to an accessory module of the bed. A remote computer can run tests and interrogate other modules of the bed to indicate problems and suggest solutions.

This diagnostic capability also enhances serviceability of the bed. The lighted LEDs indicate a specific system failure. The graphic caregiver interface

provides detailed information related to product failures on the bed. In addition, after diagnosis of the bed is performed from a remote location, a company service technician at the remote location can call an engineer at the hospital to help service the bed.

Additional objects, features, and advantages of the invention will become apparent to those skilled in the art upon consideration of the following detailed description of the preferred embodiments exemplifying the best mode of carrying out the invention as presently perceived.

Brief Description of the Drawings

The detailed description particularly refers to the accompanying figures in which:

Fig. 1 is a perspective view of a chair bed in accordance with the present invention in a bed position showing a side rail exploded away from the chair bed, head side rails and foot side rails positioned along longitudinal sides of a deck, and a swinging foot gate in a closed position;

Fig. 2 is a view similar to Fig. 1 showing the chair bed in the sitting or chair position having a head section of an articulating deck moved upwardly to a back-support position, a thigh section of the deck inclined slightly upwardly, a foot section of the deck moved to a generally vertical downwardly extending down position, a foot portion of the mattress being deflated, and swinging gates moved to an open position with one swinging gate folded next to the chair bed;

Fig. 3 is a diagrammatic view of the chair bed of Fig. 1 showing the chair bed in the bed position including a mattress having an upwardly-facing sleeping surface held a predetermined first distance above the floor, the deck being in an initial bed position supporting the sleeping

surface in a generally planar configuration, and the foot section being a first length;

Fig. 4 is a diagrammatic view showing the chair bed in a low position;

Fig. 5 is a diagrammatic view showing the chair bed in a Trendelenburg position;

Fig. 6 is a diagrammatic view showing the chair bed in a reverse Trendelenburg position;

Fig. 7 is a diagrammatic view showing the chair bed in an intermediate position having a head end of a head section of the deck pivoted slightly upward from the initial position of the deck, a seat section positioned to lie in the horizontal plane defined by the seat section in the initial position of the deck, and the foot section being inclined slightly so that the foot end of the foot section lies below the position of the foot section when the deck is in the initial position of the deck;

Fig. 8 is a diagrammatic view showing the chair bed in the chair position with the head end of the head section pivoted upwardly away from the seat section to a back-support position, the seat section lying generally horizontal as in the initial deck position, the thigh section being raised upwardly, the foot section extending downwardly from the thigh section and being a second shorter length, and the portion of the mattress over the foot section being deflated;

Fig. 9 is a block diagram illustrating the electronic control modules of the present invention connected in a peer-to-peer network configuration and illustrating the additional system components which are coupled to the various modules by discrete electrical connections;

Fig. 10 is a diagrammatical view illustrating the electrical connection from the communication network cable to a selected module and illustrating a coupler between a

pair of network connectors to facilitate adding another module to the network;

Fig. 11 is a schematic block diagram illustrating the electronic components of a bed articulation control module;

Fig. 12 is a schematic block diagram illustrating the electrical components of the scale instrument module;

Fig. 13 is a schematic block diagram illustrating the mechanical and electrical components of the bed position sense and junction module;

Fig. 14 is a schematic block diagram illustrating the components of the left and right standard caregiver interface module for either the left siderail or the right siderail;

Fig. 15 is a diagrammatical view of the lockout switches on the siderail control panel to prevent movement of selected sections of the bed; and

Fig. 16 is a schematic block diagram illustrating the mechanical and electrical components of the graphical caregiver interface module;

Figs. 17 and 18 are flow charts illustrating details of the automatic module recognition feature of the graphical caregiver interface module;

Fig. 19 is a flow chart illustrating the steps performed by the communications module for automated data collection from the other modules connected to the communication network of the bed;

Fig. 20 is a diagrammatical view illustrating a patient status module and a gateway module of the present invention; and

Fig. 21 is a diagrammatical view illustrating details of a patient charting module of the present invention.

Detailed Description

A chair bed 50 in accordance with the present invention having a head end 52, a foot end 54, and sides 56, 58 is illustrated in Fig. 1. As used in this description, the phrase "head end 52" will be used to denote the end of any referred-to object that is positioned to lie nearest head end 52 of chair bed 50. Likewise, the phrase "foot end 54" will be used to denote the end of any referred-to object that is positioned to lie nearest foot end 54 of chair bed 50.

Chair bed 50 includes a base module 60 having a base frame 62 connected to an intermediate frame module 300 as shown in Fig. 1. Casters 70, 72, 74 and 76 support the base frame 62. An articulating deck/weigh frame module 400 is coupled to intermediate frame module 300. Side rail assemblies 800, 802, 804, 806 and an extended frame module 610 having a swinging foot gate 622 are coupled to articulating deck/weigh frame module 400. A mattress 550 is carried by articulating deck/weigh frame module 400 and provides a sleeping surface or support surface 552 configured to receive a person (not shown).

Chair bed 50 is manipulated by a caregiver or by a person (not shown) on sleeping surface 552 using hydraulic system module 100 so that mattress 550, an intermediate frame 302 of intermediate frame module 300, and an articulating deck 402 of articulating deck/weigh frame module 400 assume a variety of positions, several of which are shown diagrammatically in Figs. 3-8.

Articulating deck 402 includes a head section 404, a seat section 406, a thigh section 408, and a foot section 410. Mattress 550 rests on deck 402 and includes a head portion 558, a seat portion 560, a thigh portion 562, and a foot portion 564, each of which generally corresponds to the like-named portions of deck 402, and each of which

is generally associated with the head, seat, thighs, and feet of the person on sleeping surface 552.

Chair bed 50 can assume a bed position having deck 402 configured so that sleeping surface 552 is planar and horizontal, defining an initial position of deck 402 as shown in Fig. 1 and as shown diagrammatically in Fig. 3. In the bed position, sleeping surface 552 is a predetermined first distance 566 above the floor. Chair bed 50 can also be manipulated to assume a low position shown diagrammatically in Fig. 4 having deck 402 in the initial position and having sleeping surface 552 a predetermined second distance 568 above the floor, the second distance 568 being smaller than first distance 566. The foot deck section 410 of the articulating deck 402 includes a pivoting portion 466 and a contracting portion 462. Foot deck section 410 has a first length 465 when the deck 402 is in the initial position.

Chair bed 50 can be moved to a Trendelenburg position shown diagrammatically in Fig. 5 having deck 402 in a planar configuration and tilted so that head end 52 of sleeping surface 552 is positioned to lie closer to the floor than foot end 54 of sleeping surface 552. Chair bed 50 can also achieve a reverse Trendelenburg position shown diagrammatically in Fig. 6 having deck 402 in a planar configuration and tilted so that foot end 54 of sleeping surface 552 is positioned to lie closer to the floor than head end 52 of sleeping surface 552.

As described above, chair bed 50 is convertible to a sitting or chair position shown in Fig. 2 and shown diagrammatically in Fig 8. In the chair position, head end 52 of head section 404 of deck 402 is pivoted upwardly away from intermediate frame 302 to a back-support position providing a pivotable backrest so that head section 404 and intermediate frame 302 form an angle 512 generally between 55 and 90 degrees. Seat section 406 of deck 402 is

positioned to lie generally horizontally as in the initial position, foot end 54 of thigh section 408 is slightly upwardly inclined, and foot section 410 of deck 402 extends generally vertically downwardly from thigh section 408 and has a length 464 that is shorter length 465 than when deck 402 is in the initial position. Foot portion 564 of mattress 550 is inflatable and is in a deflated condition when chair bed 50 is in the chair position. Foot portion 564 of mattress 550 is thinner and shorter when deflated than when inflated.

Chair bed 50 is capable of assuming positions in which head, thigh, and foot sections 404, 408, 410 of deck 402 are in positions intermediate to those shown in Figs. 3 and 8. For example, chair bed 50 can assume an intermediate position shown diagrammatically in Fig. 7 having head end 52 of head section 404 of deck 402 pivoted slightly upwardly from the initial position, seat section 406 positioned to lie in the same generally horizontal plane as in the initial position, foot end 54 of thigh section 408 raised slightly upwardly from the initial position, and foot section 410 being inclined so that foot end 54 of foot section 410 lies below head end 52 of foot section 410.

Fig. 9 is a block diagram illustrating the plurality of electronic control modules for controlling operation of the hospital bed. As discussed above, the plurality of modules are electrically coupled to each other using a twisted pair network channel in a peer-to-peer configuration. The peer-to-peer network extends between first and second network terminators 1012 and 1013. The network connections are illustrated by the solid black lines in Fig. 9. Discrete connections to each of the modules are illustrated by the dotted lines in Fig. 9. The bold line of Fig. 9 illustrates an AC power connection.

Network terminator 1012 is coupled to an air supply module 1014. Air supply module 1014 is coupled via the network cable to accessory port module 1016. Accessory port module 1016 is coupled to the bed articulation control module (BACM) 1018. BACM 1018 is coupled to a communications module 1020. Communications module 1020 is coupled to scale instrument module 1022. Scale instrument module 1022 is coupled to surface instrument control module 1024. Surface instrument module 1024 is coupled to position sense and junction module 1026. Position sense module 1026 is coupled to the network terminator 1013. A left side standard caregiver interface module 1028 is also coupled to the network by a connection in position sense module 1026. The right side standard caregiver interface module 1030 and the graphic caregiver interface module 1032 are also coupled to the network using a connection in the position sense module 1026.

It is understood that the modules can be rearranged into a different position within the peer-to-peer network. The modules are configured to communicate with each other over the network cable without the requirement of a master controller. Therefore, modules can be added or removed from the network without the requirement of reprogramming or redesigning a master controller. The network recognizes when a module is added to the network and automatically enables a control interface such as graphic caregiver interface module 1032 to display specific module controls for the added module. This eliminates the requirement for controls on individual modules. The module recognition feature is discussed in detail below.

Each module is connected to its appropriate sensors and actuators so that it can perform its dedicated function. The following is a brief description of each electronic module:

Power for the communication network is supplied by a power supply and battery charge module 1062. Power supply 1062 is coupled to a power entry module 1063 and an AC main plug 1065. Power Supply/Battery charge module (PSB) 1062 converts the AC Mains input 1065 to DC levels to be used by the electronic modules. PSB 1062 contains filtering for the AC Mains 1065 at the Mains entry point 1063. The PSB 1062 also provides power for limited bed functionality upon removal of the AC Mains power input via a battery 1067. The PSB 1062 contains an automatic battery charging circuit with output to indicate battery status (i.e., battery dead, battery low, battery OK). PSB 1062 also controls the hydraulic pump 1055.

Bed Articulation Control Module (BACM) 1018 - The BACM 1018 primarily controls the hydraulic system used to articulate the bed. BACM 1018 accepts inputs from various user interfaces located throughout the bed to control bed articulations. This control input is qualified with a position sensing input representing the actual locations of the bed deck sections, along with patient lockout controls, to determine whether the bed should articulate. The BACM 1018 is present in every bed. BACM includes a real time clock circuit to set the time for various other modules.

Position Sense module 1026 detects the angles of all the appropriate bed deck sections. In addition, it interfaces to the bed exit detect, and the four (4) side rail UP sensors. The position sense module 1026 outputs this information to the network. These functions may be incorporated into the BACM 1018 and Bed-Side Communications Interface module 1020. The position sense module 1026 also provides the interconnections of the bed network and hospital communications links to the siderail standard caregiver interface 1028 and 1030 modules.

Siderails (SIDE) - The siderails will contain standard caregiver interface modules 1028 and 1030

consisting of input switch controls, output status indicators, and an audio channel. The standard caregiver interface modules 1028 and 1030 are coupled to patient control mechanisms for bed articulations, entertainment, surface, lighting, Bed Exit, and Nurse Call.

Scale Instrument Module 1022 translates the signals from the embedded load beams into actual weight measured on the weigh frame. Scale module 1022 outputs this weight to the Graphic Caregiver Interface Module (GCI) 1032 for display purposes. This weight is also available to the communications module 1020 for transmittal to the hospital information network. Scale module 1022 includes Bed Exit and weight gain/loss alarm detection capability.

Surface Instrument Module 1024 controls the dynamic air surface. It will accept input from the GCI 1032 to dictate system performance characteristics. Surface module 1024 uses the GCI 1032 to display outgoing system information. Surface instrument module 1024 also interfaces with the air supply module 1014 to control the air handling unit 1046.

Sequential Compression Device (SCD) - This module will control the optional compression boots. It will use the GCI 1032 for interfacing to the caregiver.

Graphic Caregiver Interface Module (GCI) 1032 controls the scale 1022 and surface module 1024 (including SCDs). In addition, GCI 1032 provides control input and text and graphic output capability for future design considerations. GCI 1032 utilizes a graphic display along with a software menu structure to provide for full caregiver interaction.

Communications module 1022 is the gateway between the patient's environment controls and bed status information residing on the bed, and the hospital information/control network.

Bed Exit Sensor (BES) 1069 exists on non-scale beds. The BES connects to the position sense module 1026 to detect a patient bed exit.

Brake-Not-Set Sensor (BNS) 1056 detects the state of the Brake/Steer Pedal. It is connected to the BACM 1018.

Bed-Not-Down Sensor (BND) 1058 detects if the bed is fully down (both Head and Foot Hilo). It is connected to the BACM 1018.

Side Rail Up Detect Sensors (SUD) 1071 consists of four switches to detect the secure UP position of the side rails. The SUD 1071 is connected to the position sense module 1026.

Night Light 1073 is a stand alone unit providing the night light function. It is powered by low voltage AC coming from the Power Supply/Battery module 1062.

Pendant 1048 provides for bed articulation control input through accessory port module 1016.

Patient Assist Arm Control 1050 is a functional equivalent of the standard caregiver interface modules 1028 and 1030 controls in a different physical embodiment. The assist arm includes a control pad coupled to the accessory module 1016.

The air supply module 1014, the bed articulation control module 1018, the power supply module 1062, and the power entry module 1063 are all coupled to the base frame of the hospital bed. The communications module 1020, the scale instrument 1022, and the remote information interface 1124 are all coupled to the intermediate frame. The left standard caregiver interface 1028 and patient interfaces 1154 and 1156 are all coupled to the left siderail. The right standard caregiver interface 1030 and patient interfaces 1158 and 1160 are all coupled to the right siderail. Graphical caregiver interface module 1032 may either be coupled to the left siderail or the right

siderail. The position sense module 1026 and surface module 1024 are each coupled to the weigh frame. It is understood that the position of each module can be changed.

Fig. 10 diagrammatically illustrates how the various modules are added and removed from the network. The electronic network uses an Echelon LonTalk serial communications protocol for module to module communication in the bed. The cable 1034 illustrated in Fig. 10 contains power and a twisted pair connection. The preferred protocol is RS-485 with a transmission speed of 78 kbs. The cable 1034 is provided with connectors 1036. Extra connectors 1036 are provided for module additions. When the connectors 1036 are not coupled to a module, a coupler 1038 is provided to interconnect adjacent connectors 1036. In order to connect a particular module 1040 to the network, the coupler 1038 is removed and connectors 1036 are coupled to mating connectors 1042 of the module 1040. Connectors 1042 are electrically coupled within the module 1040 as illustrated by dotted line 1044.

Referring again to Fig. 9, air supply module 1014 is coupled to an air handling unit 1046 by a discrete electrical connection. Air supply module 1014 controls compressor 1046 to inflate and deflate the mattress surface of the bed as discussed in detail below (or in main application).

The accessory port module 1016 provides connections to the network for a pendant 1048, an assist arm control 1050, or a diagnostic tool 1052. Pendant 1048 is a hand held control unit which is movable from bed to bed. Therefore, pendant 1048 may be coupled and uncoupled from accessory port module 1016 to control various functions of the bed. For example, the accessory port module 1016 can communicate with BACM 1018 to control movement of the bed. Assist arm controls 1050 provide input to accessory port module 1016 from a control pad

coupled to an assist arm extending out over the patient support surface of the bed. The assist arm 1050 can be used to control movement of the bed, as well as for other desired functions. The pendant 1048 and assist arm control 1050 may include all the controls of the right and left standard caregiver interface modules discussed below.

Diagnostic tool 1052 is used for servicing the bed, either at the bed site or from a remote location. A modem is coupled to accessory port module 1016 to provide a telephone line connection to the hospital bed. This permits information related to the bed from any module to be retrieved from the peer-to-peer network at a remote location. For instance, the amount of time that the surface of the bed is in use may be detected at the remote location through the modem for billing purposes. The diagnostic tool 1052 permits a remote operator to interrogate every module of the electrical control network. The diagnostic tool 1052 checks application dependent parameters, runs each of the modules through a test procedure, and fully accesses all network information. Diagnostic tool 1052 may be a hand held tool such as a lap top computer which is coupled directly to accessory port module 1016. In addition, a remote computer can be coupled to accessory port 1016 with the modem link to provide a data link to the network. A Voice Mate™ control system available from Hill-Rom, Inc. may also be coupled to accessory port module 1016 to control the bed.

The bed articulation control module (BACM) 1018 is the module that controls movement of the bed. BACM 1018 controls actuation of a plurality of solenoids 1054 which open and close valves coupled to hydraulic cylinders to move the articulating deck sections of the hospital bed relative to each other. BACM 1018 is also coupled to a Break Not Set sensor 1056 and a Bed Not Down sensor 1058. When BACM 1018 receives an input signal from the network

requesting movement of the bed to a predetermined position, the BACM 1018 first reads the position of the bed provided from position sense module 1026. If movement of a portion of the bed is necessary, BACM 1018 checks for a lockout signal from the left and right standard caregiver interface modules 1028 and 1030. If the lockouts are not set, BACM 1018 controls activation of the selected solenoid 1054 and then BACM 1018 turns on the hydraulic pump 1055 (gravity may also be used if appropriate) to actuate a selected cylinder if necessary.

Details of the BACM 1018 are illustrated in Fig. 11. BACM 1018 includes a neuron controller 1060. Illustratively, neuron controller 1060 is a MC143150FU echelon neuron networking microprocessor available from Motorola. Controller 1060 is coupled to the network through an RS-485 transceiver 1061. BACM 1018 operates to move a plurality of solenoids 1054 in a hydraulic manifold to open and close control valves coupled to the hydraulic cylinders and articulate the bed based on various network commands received from the peer-to-peer network. Neuron controller 1060 receives commands from the right and left siderail standard caregiver interface modules 1028 and 1030, the graphic caregiver interface 1032, or from another input device to articulate the bed. Neuron controller 1060 also receives other information from the network regarding the position of the head, seat, thigh, and foot deck sections of the articulating deck of the bed. Therefore, neuron controller 1060 controls the solenoids and pump to stop articulating the bed as a limit is reached or when the particular bed section reaches its desired or selected position.

Both the articulating deck of the bed and the height of the deck are controlled by the BACM 1018. Upon receiving a bed function command from the network, the BACM 1018 energizes the appropriate solenoids and provides a

control signal to the Power Supply/Battery Module 1062 illustrated in Fig. 9 to power the hydraulic pump, if necessary. BACM 1018 may use bed position information provided by the remotely mounted bed position transducers. Alternatively, the position of the various sections of the articulating deck may be supplied to BACM 1018 by the position sense module 1026. BACM 1018 also instructs air supply module 1014 and surface control module 1024 via the network to partially deflate a seat section and a foot section of the mattress when the bed moves to a chair position. BACM 1018 also receives lockout information from the siderail standard caregiver interface modules 1026 and 1028 to determine whether or not a particular section of the articulating deck should move.

Neuron controller 1060 executes code stored in EPROM 1064. Illustratively, EPROM 1064 is a 27C256-70 EPROM available from AMD. In order to conserve power, BACM 1018 uses a pulse width modulation (PWM) control system to minimize the current draw required to actuate the solenoids 1054. Conventional control systems simply turn the solenoid 1054 full on or full off and, as the voltage varies, current consumption goes up and down accordingly. With the PWM control design of the present invention, as the voltage varies BACM 1018 controls the power that is applied to the solenoid 1054 to maintain substantially the same current level to minimize power consumption. Neuron controller 1060 controls a timing generator 1066 through a memory map address decoder 1068. Memory map address decoder 1068 provides a signal to timing generator 1066 on line 1070 to start PWM and provides a signal on line 1072 to timing generator 1066 to stop PWM. Neuron controller 1060 provides a 5 or 10 MHz clock signal to timing generator 1066 on line 1074.

Timing generator 1066 provides six different time periods in which to actuate one of six pairs of solenoids

1054 used to control the valves of the hydraulic cylinders. Each time period is about 50 milliseconds. Only one solenoid 1054 can be pulled during any one time period. This minimizes the maximum current draw on the power supply or battery at any given time. It is understood that a different number of solenoid pairs may be controlled in accordance with the present invention. The number of time periods and the time period intervals may be changed, if desired. In the illustrated embodiment, six pairs of solenoids are controlled by the BACM 1018. One solenoid of each pair is used to open a first valve to control movement of a deck section in a first direction, and the other solenoid of each pair is used to open a second valve to control movement of the particular section in an opposite direction. Therefore, a pair of solenoids is provided for the head section cylinder, the foot section cylinder, the foot Hi Lo cylinder, the head Hi Lo cylinder, the knee section cylinder, and the foot retracting section cylinder.

Timing generator 1066 supplies a PWM enable signal on line 1076 to a solenoid PWM select logic control circuit 1078. Timing generator 1066 also provides time division terms to PWM control circuit 1078 on line 1080.

Illustratively, there are twelve different solenoids 1054 powered by FET drivers 1090. Neuron controller 1060 can provide three separate commands for each solenoid. The commands include an extend command, a retract command, and a pull-in command. The extend command is used to select the correct solenoid which when energized will extend the appropriate cylinder. Steady-state control of the FET which powers the solenoids is pulsed ON and OFF at the PWM rate. The retract command is used to select the opposing solenoid which when energized retracts the cylinder. It too is turned ON and OFF at the PWM rate. When a solenoid is initially activated or turned on, it is desirable to actuate the selected solenoid at "full on" for

a predetermined time. Therefore, the pull-in command overrides the PWM control circuit.

Data including the control commands (pull-in, extend, or retract) for a selected solenoid 1054 transmitted from the neuron controller 1060 is written to buffer register 1084. To synchronize the commands stored in the buffer register 1084 with the timing pulses from timing generator 1066, the commands are shifted into a holding register 1088. Therefore, asynchronous information is received in buffer register 1084. This asynchronous information is synchronized into the holding register 1088 using a timing generator pulse on line 1094. The timing signal 1094 synchronizes the pull-in latch 1082 in buffer register 1084 and the pull-in latch 1086 in the holding register 1088 with the timing generator 1066. Timing signal 1094 also synchronizes the solenoid "extend" latches 1096 and 1098 and the solenoid 1054 "retract" latches 1100 and 1102 with the timing generator 1066.

The PWM select logic control circuit 1078 receives commands from the holding register 1088 and provides signals to drive a discrete FET through FET drivers 1090 during each timing interval of the PWM timing generator 1066. Driver 1090 pulls the selected solenoid 1054 down to ground and applies a voltage across the selected solenoid 1054 to control the solenoid. A voltage clamp 1104 is coupled to each of the solenoids 1054. When power is removed from a particular FET an inductive signal is supplied to the solenoids 1054. Voltage clamp 1104 clamps the inductive signal to the voltage rail. Therefore, voltage clamp 1104 provides voltage spike suppression.

A diagnostic block 1106 also receives current signals related to each pair of solenoids 1054 from voltage clamp 1104 on line 1105. Only one solenoid 1054 in each pair can be controlled or actuated at any given time.

Diagnostic block 1106 also receives a data command signal from neuron controller 1060 on line 1108 indicating the particular solenoids 1054 which are designated by the controller 1060 for activation. Therefore, diagnostic block 1106 compares the actual information received from the solenoid 1054 pairs to the data received on lines 1108. If the actual solenoid 1054 current does not match the desired solenoid 1054 activation data from controller 1060, diagnostic block 1106 sends a signal to neuron controller 1060 on line 1110. A signal on line 1110 actuates a signal on supervisory line 1112 coupled to a master FET 1114 to turn off the master FET 1114 and shut off power to all the solenoids 1054. The master FET 1114 is coupled in line with all twelve solenoids 1054. Therefore, supervisory FET must be turned on to provide power to any one of the solenoids 1054.

A current sense resister 116 is coupled to the FET drivers 1090. The current sense resister 116 is coupled to the first input terminal of a comparator 1118. A second input terminal of comparator 1118 is coupled to a reference voltage. The output of comparator 1118 provides PWM feedback signal to timing generator 1066 on line 1120. In order to provide PWM, the current must be measured in each solenoid 1054. Therefore, the current sense resister 116 measures the current in each of the six time slots used for controlling the solenoids 1054. Depending on the measured current, the signal on line 1120 adjusts the timing generator 1066 to control the pulse width of the driver signal. Therefore, if too much current is being drawn, then timing generator 1066 shortens the width of the driver pulse in order to bring the current down.

Referring again to Fig. 9, communications module 1020 provides an interface needed for bed-to-hospital or hospital-to-bed information transfer. Communications module 1020 is a gateway between the bed network and the

hospital information/control network. Communications module 1020 is connected to a standard side-com interface 1122. Interface 1122 also provides direct hard wired links between the nurse call switches on the side rails of the bed and the hospital priority nurse call network. Signals from these nurse call switches can also be sent over the network. On beds without a scale, a switch input port is provided to accept a bed exit signal coming from a bed exit sensor.

Interface 1122 supports all existing discrete wire protocols. Interface 1124 will support newly defined serial protocols, both to hospital network and other hospital room equipment. Any other hospital room equipment can use the GCI module 1032 as its user interface control module.

Communications module 1020 also provides entertainment functions. Television, radio, or the like may be controlled by communications module 1020 based on input/output signals received/sent from the left or right siderail standard caregiver interface modules 1028 and 1030 over the network or via discrete connections.

Communications module 1020 is directly coupled to the hospital information electrical network to transmit and receive signals from a remote location. Communications module 1020 receives weight information from scale instrument module 1022. Communications module also receives surface setting information, including pressures and other parameters from surface instrument module 1024. Communications module 1020 also receives bed position information from position sensing module 1026. In addition, communications module 1020 can receive all information travelling on the network.

The hospital network can drive a display on the graphic caregiver interface 1032 using signals transmitted from the remote location through a remote information

interface 1124, to communications module 1020, and then to graphic caregiver interface 1032 over the network. Therefore, communications module 1020 provides an interactive data link between the remote location and the graphic caregiver interface module 1032. Requests for weight acquisition can be automatically sent from a remote location through remote information interface 1124 and communications module 1020. Communications module 1020 then communicates with scale instrument 1022 to determine the weight and then transmits the weight to the remote location via the remote information interface 1124.

The scale instrument module 1022 receives input signals from load beams coupled to a weigh frame of the bed. Specifically, scale instrument module 1022 receives input signals from a left head load beam 1126, a right head load beam 1128, a right foot load beam 1130, and a left foot load beam 1132. The scale module 1022 transmits weight information and operation parameters to the GCI module 1032 and communications module 1020. Load beams 1126, 1128, 1130, and 1132 are bolted to the intermediate frame. The articulating deck and weigh frame module is then bolted to the load bearing ends of the load beams. Any item attached to or resting on the articulating deck and weigh frame will be weighed by the load beams. Scale instrument module 1022 receives information from the network via a nurse caregiver interface unit or a graphic caregiver interface module 1032. The scale acquires data from the load beam transducers 1126, 1128, 1130, and 1132 and automatically factors in the tare weight to calculate a patient weight. Scale module 1022 transmits an output signal to the network representing the patient weight. Scale module 1022 can detect bed exit and alert the hospital via the communications module 1020 and remote information interface 1124.

Scale module 1022 also provides a weight change alarm. Scale module 1022 accepts a set point weight from the network. Scale module 1022 detects if a patient's weight change has exceeded or dropped below a preset level from the initial set point weight. If a preset weight change has occurred, scale module 1022 provides an alarm message to the network. Scale module 1022 stores all data critical to the functioning of the scale in non-volatile memory. Scale module 1022 has built in diagnostic capability to detect hardware integrity and data integrity.

Details of scale module 1022 are illustrated in Fig. 12. The four load cells 1126, 1128, 1130, and 1132 are coupled to a four channel analog to digital converter 134. Illustratively, analog to digital converter is a CS5516,4 MHz analog to digital converter available from Crystal Semiconductor. Analog to digital converter 134 converts analog signals from the load cells 1126, 1128, 1130, and 1132 into digital signals and inputs the signals into the echelon neuron controller 1136. Neuron controller 1136 is a MC143150,10 MHz networking microprocessor available from Motorola. Controller 1136 executes code stored in an EPROM 1138. Illustratively, EPROM 1138 is a 32K X 8, model 27HC256 EPROM available from AMD.

Neuron controller 1136 stores calibration data related to each of the load cells 1126, 1128, 1130, and 1132 either in its internal memory or in external EEPROM 1140. Calibration data is necessary because each load beam 1126, 1128, 1130, and 1132 has slightly different gain or offset constant associated with it. Calibration/excitation relay 1142 transmits the calibration data from neuron controller 1136 to analog to digital converter 1134. Two connectors 1148 and 1150 are provided to couple scale module 1022 to the peer-to-peer communication network. Connector 1148 is hard wired to connector 1150. An RS-485 transceiver 1149 is coupled between connectors 1148 and

1150 and controller 1136. Transceiver 1149 takes logic inputs and outputs and converts them to RS-485 level signals for the network. For each of the modules on the peer-to-peer network, a connecter such as connector 1148 is hard wired to another connector such as connector 1150 that goes onto the next node or module in a daisy chain configuration. Scale module 1022 also includes a +5VDC regulated power supply 1152.

Referring again to Fig. 9, the surface instrument module 1024 is provided for controlling operation of the mattress or support surface. Details of this module are discussed below with reference to the surface design (or in main application).

The bed includes position transducers mounted throughout the bed to sense any needed positions of individual bed sections for articulation and caregiver interface purposes. The position sense module 1026 also interfaces a Side Rail Up Detect Sensor, and a Bed Exit Sensor.

Details of the position sense module 1026 are illustrated in Fig. 13. Illustratively, the position transducers are discrete tilt sensors on various deck sections of the bed. The sensors include a trendelenburg limit sensor at 13° relative to earth, a reverse trendelenburg sensor at -13° relative to earth, and a bed-level at 0° relative to earth. In addition, the articulating deck sections include position transducers which are also discrete tilt sensors. Illustratively, the tilt sensors are model A½ sensors available from AEC. The patient head limit sensor detects the head section at 55° relative to earth. The head contour limit sensor detects the head section at 30° relative to earth. The knee contour limit detects the knee section at 12° relative to earth. The patient foot limit detects the position of the foot section at 30° relative to earth.

The sensor inputs are coupled to the position sense module 1026. The sensor input signals are signed conditioned using a RC filter 1154. The output of RC filter 1154 is coupled to a neuron controller networking microprocessor 1156. An output from controller 1156 drives a local alarm 1158. Input power on line 1160 is coupled to a regulated power supply 1162 which produces a +5V output. The output from power supply 1162 is coupled to neuron controller 1156 and to a network transceiver 1164. The position transducers illustratively switch from a logic high to a logic low upon detection of the particular angle relative to earth.

Controller 1156 transmits and receives network information through transceiver 1164. Network transceiver 1164 is coupled to a first network connector 1165 via lines 1166. Position sense module 1126 also provides the connection points to the network for the left and right standard caregiver interface modules 1028 and 1030. Network connector 1165 also coupled to a left siderail network connector 1170 which is coupled to the left siderail standard caregiver interface module 1128. Left siderail connector 1170 is coupled to a right siderail connector 1172 by lines 1171. Connector 1172 is coupled to a right siderail standard caregiver interface module 1030. Connector 1172 is also coupled to a second network connector 1173 by lines 1175. Therefore, position sense module 1026 is also a junction module for connection to the left and right side rail standard care giver interface modules 1028 and 1030.

During operation, neuron controller 1156 interprets the sensor signals received from RC filter 1154 and sends an output signal indicative of the state of each sensor to the network through network transceiver 1164. Network transceiver 1164 is a RS-485 protocol transceiver. Alarm 1158 contains a piezo device so that any alarms on

the bed that are transmitted through the network turn on the piezo alarm on the position sense module 1026. These alarms may include bed exit, patient weight gain, weight loss, surface pressure loss, or other desired alarms. Alarm 1158 can also be used to alert an operator when catastrophic failures are detected in the bed by the diagnostic tools.

The left and right standard caregiver interface modules 1028 and 1030 are substantially identical. The left standard caregiver interface module 1028 is coupled to patient controls including an articulation and entertainment interface in the left siderail as illustrated at block 1154 of Fig. 9. Standard caregiver interface module 1028 is also coupled to a surface patient interface on the left side rail as illustrated at block 1156. The standard caregiver interface module 1030 for the right side is coupled to articulation and entertainment patient interface module on the right siderail as illustrated at block 1158. The right standard caregiver interface module 1030 is also coupled to a surface patient interface caregiver interface on the right side rail as illustrated at block 1160.

Details of the left standard caregiver interface module 1028 is illustrated in Fig. 14. The standard caregiver interface module includes an echelon controller 1162 which is a networking microprocessor. Echelon controller 1162 is coupled to a +5.0V supply voltage from power supply 1164. Echelon controller 1162 is also coupled to a network transceiver 1166. Transceiver 1166 is an RS-485 protocol transceiver. Transceiver 1166 couples controller 1162 to the peer-to-peer communication network as illustrated at line 1168. A network connection for the graphic caregiver interface module 1032 is provided at line 1170 for both the left and right standard caregiver interface modules 1128 and 1030. Graphic caregiver

interface module 1032 can be connected on either the left or right side of the bed. Echelon controller 1162 interprets the network messages. Network controller 1162 also detects switch activation from the articulation and entertainment patient interface 1154 and the surface patient interface 1156 and transmits output signals to the network on line 1168. The switches can be dead function switches, lockout switches, bed exit switches, nurse call backlit switches, and so on. Controller 1162 drives a LED driver 1172 to light indicator LEDS 1174 related to various bed status functions, such as bed-not-down, brake-not-set, battery low, and service required.

The LED driver 1172 is also coupled to a backlighting switch 1176 of the articulation and entertainment patient interface 1154. Backlighting switch 1176 is coupled to backlighting LEDs 1178. Backlighting switch 1176 is also coupled to backlighting LEDs 1180 on the surface patient interface 1156.

The standard caregiver modules 1028 and 1030 connect all the caregiver interfaces switches in a row/column type architecture to provide a 4 X 10 matrix. A keyboard row selection logic circuit is used to detect switch presses as illustrated at block 1182.

The standard caregiver interface (SCI) modules 1028 and 1030 include the network circuitry for interfacing all caregiver and patient siderail caregiver interfaces to the communication network. The patient caregiver interfaces are separated into modules which can be connected to the SCI module 1028 or 1030 in a modular fashion.

Each SCI module 1028 and 1030 includes bed articulation switches 1184. These include head up, head down, knee up, knee down, foot up, foot down, bed up, bed down, chair in, chair out, trendelenburg, and reverse trendelenburg. In the case of a switch closure, a signal

is periodically output to the network until the opening of the switch occurs. The SCI modules 1028 and 1030 further include lockout switches 1186 as discussed below, bed exit switches 1188, nurse call switches 1190, and backlighting switches 1192. Control buttons for the switches 1184, 1186, 1188, 1190, and 1192 are typically on an outside portion of the siderail for use by a nurse.

The articulation and entertainment patient interface 1154 also includes a nurse call switch 1194, interactive TV switches and a light switch 1196, and bed articulation switches 1198. Surface patient interface 1156 includes nurse call LEDs 1200, mattress switches 1202, and a nurse call switch 1204.

As discussed above, the lockout control switches are located on the left and right siderail control interfaces. As illustrated in Fig. 15, the lockout control includes a global enable lockout activation switch 1205 which must be pressed in order to activate any of the other lockout toggle switches for the foot control lockout 1207, the knee control lockout 1209, the head control lockout 1211, or the lockout for all controls at 1213. This double lockout activation reduces the likelihood of the accidental deactivation of one of the lockout control switches. Therefore, the global enable switch 1205 must be pressed in order to turn any of the other lockout controls on or off. The global enable switch 1205 automatically deactivates after about 5 seconds of inactivity. After the global enable is deactivated, the lockout status cannot be changed. Since the caregiver controls are within reach of a patient, the global enable switch may be used to enable and disable both the patient and caregiver bed articulation control switches.

A graphic caregiver interface (GCI) module 1032 is illustrated in detail in Fig. 16. The GCI module 1032 provides an enhanced menu-driven caregiver input and output

for bed articulation, scale, surface caregiver interface, and sequential compression device controller, and all other modules needing this type of user interface. The GCI module 1032 includes a LCD display 1206, which is illustratively a 320 X 240, model DMF 50081 available from Optrex. Display 1206 may also be a 320 X 240, model G321EX available from Seiko. Display 1206 outputs graphical information to the caregiver. A switch panel 1208 permits the caregiver to input information into the GCI module 1032. Switch panel 1208 may be a series of discrete switches or an alpha/numeric keypad. Switch panel 1208 is coupled to a connector 1210. Connector 1210 is coupled to an input of CPU 1212. CPU 1212 is illustratively an 80C188XL, 10 MHz CPU available from Intel. The input device for the caregiver may also be an encoder 1214 which is coupled to a connector 1216. Connector 1216 is coupled to CPU 1212. Illustratively, encoder 1214 is a rotary encoder.

Connection to the peer-to-peer communication network is provided at terminal 1218. The network connection is made to a RS-485 transceiver 1220. Transceiver 1220 is coupled to a +5 VDC regulated power supply 1222. Transceiver 1220 is also coupled to a +12VDC regulated power supply 1224. Transceiver 1220 is coupled to an echelon neuron controller networking microprocessor 1226. Controller 1226 is illustratively an AMC143120, 10 MHz networking microprocessor available from Motorola. Neuron controller 1226 is coupled to an I/O test port 1228. Controller 1226 is also coupled to CPU 1212. Software code for operating CPU 1212 is stored in an EPROM memory 1230. Illustratively, memory 1230 is a 512K X 8 flash EPROM memory. Data is stored in static RAM memory 1232. Illustratively, memory 1232 is a 128K X 8 memory chip. Additional memory is provided in a 2K X 8 EEPROM 1234. An output from CPU 1212 is coupled to a LCD backlight inverter

1236. Backlight inverter 1236 is coupled to LCD display 1206 by connector 1238. Backlight inverter facilitates viewing of display 1206 in all types of room lighting. Inverter 1236 is configured to match the particular display 1206 selected.

CPU 1212 is also coupled to a LCD controller 1240. LCD controller 1240 drives the display 1206 through a connector 1242. Controller 1240 is coupled to a 32K X 8 static video RAM 1244. As the CPU 1212 writes an image to LDC controller 1240, the controller 1240 stores the image in VRAM 1244 and then continuously refreshes the display screen 1206 with the image stored in the VRAM 1244.

Contrast of the display 1206 is controlled by software contrast adjustment as illustrated at block 1246. A LCD bias supply voltage at block 1248 is coupled to connector 1242. Supply 1248 converts a +5V input or a +12V input into a -22V output. An external watchdog timer 1250 monitors CPU 1212. If the CPU 1212 does not pulse the particular line on a periodic basis, timer 1250 resets the system.

GCI module 1032 also includes a diagnostic port 1252. Diagnostic port 1252 is coupled to CPU 1212 through a serial port 1254. Serial port 1254 is a RS-232 UART. Therefore, a laptop may be connected at port 1252 to interrogate the CPU 1212. CPU 1212 can access and send information to the network through controller 1226.

The GCI module 1032 provides an enhanced menu-driven caregiver input and output control for bed articulation, scale, surfaces, sequential compression devices, and all other modules needing this user interface capability. The GCI module 1032 is intended to be a drop in replacement for Scale/Surface Nurse Control Unit. GCI module 1032 interacts with scale module 1022. Specifically, GCI module 1032 can transmit a request for patient weight to the scale module 1022. In addition, the

GCI module 1032 can also zero the scale and perform other scale module functions.

GCI module 1032 stores predetermined graphics data and caregiver interface data in memory 1230. This predetermined graphics data is stored in the GCI module 1032 at the time of production. Additionally, other modules on the peer-to-peer communication network can download screen formats to the GCI module into static RAM 1232. The GCI module then retrieves the stored graphic screen formats either from memory 1230 or static RAM 1232 and displays the output on display 1206. By providing stored built-in graphics in memory 1230, the GCI module 1032 can support products or other modules that may later be connected to the peer-to-peer communication network. By providing the stored predetermined graphic formats, the GCI module 1032 does not have to be updated each time a new module is added to the system. If the desired graphics format is not present in memory 1230, then the newly added module must download the desired graphic formats into RAM 1232 at run time.

The specific graphic formats stored in the GCI module 1032 can include charting formats such as bar graphs, X-Y graphs, pie charts, etc., icons or pictures representing each of the modules in the communication network, or any other type of graphical format desired. Graphic formats for use by the modules are stored in two different ways in the GCI module 1032. Typically, these various graphic formats are stored in EPROM 1230 at the time of manufacture. In other words, these graphical formats are typically designed into the GCI module 1032. If a particular GCI module 1032 does not include the desired graphic format stored in memory 1230, then the particular graphic format for the new module added to the system is downloaded into the static RAM 1232 of GCI module 1032 after the bed is powered up. For instance, if GCI

module 1032 does not include a X-Y graphic format in memory 1230, this graphic format can be downloaded into RAM 1232 after the bed is powered up. Once a particular graphic format is stored in GCI module 1032, in either memory 1230 or RAM 1232, the new module transmits only data to the GCI module 1032 during operation. The GCI module 1032 uses the received data and the stored graphic format to produce an appropriate screen output on display 1206. For instance, after the X-Y graphic format is stored in either memory 1230 or RAM 1232, the particular module transmits only the X-Y data to the GCI module 1032 over the network. The GCI module 1032 then uses this data along with the stored X-Y graphic format to provide an output to display 1206. Each new module will also download a particular icon representative of the new module for the menu-driven display 1206 of GCI module 1032 as discussed below.

Updating of the graphic formats and menu information of the GCI module 1032 can be accomplished in one of three ways. The particular graphic format and menu information can be downloaded into static RAM 1232 at power up of the bed. The graphic format and menu information can also be downloaded to EEPROM 1234 during installation of a new module. Finally, EPROM 1232 can be changed to include the new graphic format and menu information at the time the new module is installed.

Details of the operation of GCI module 1032 for automatically recognizing and controlling newly added modules on the communication network are illustrated in Figs. 17 and 18. Bed power up is illustrated at block 1260. A graphics status flag and a menu saved status flag are both cleared at block 1262. These flags provide an indication of whether a particular graphic format or menu information for the module must be downloaded to the GCI module 1032. For each module on the network, menu screens will be provided on display 1206. Therefore, if a

particular module is selected using the GCI module 1032, control options for that module will appear as menu items on display 1206. Once a particular control option is selected, additional menu items for the selected control option may appear, and so on.

GCI module 1032 performs a system query at block 1264. GCI module 1032 first determines whether any modules are present on the communication network which use the GCI module 1032 as illustrated at block 1266. If no modules are present on the network which use the GCI module 1032, the GCI module 1032 returns to block 1264. The system query is carried out at predetermined time intervals.

If modules are present which use the GCI module 1032 at block 1266, the GCI module 1032 determines whether any of the modules need to download graphic formats to the GCI module 1032 as indicated at block 1268. If no modules need to download graphic information, GCI module 1032 advances to block 1274. If any of the modules need to download graphic formats, the graphic formats are downloaded to static RAM 1232 of GCI module 1032 as illustrated at block 1270. The graphics status flag for the module is then updated as illustrated at block 1272. The graphics status flag is initially generated at block 1266 during detection of any modules which use the GCI module. Therefore, after step 1270 the status flag 1272 indicates that all the graphic format data for the particular module is now stored on the GCI module 1032.

GCI module 1032 next determines whether any of the modules need to download menu structure information to the GCI module. If not, GCI module 1032 advances to block 1280 in Fig. 18. If any of the modules need to download menu structure information, the appropriate menu structure information is downloaded to the static RAM 1232 of GCI module 1032. This menu structure information provides the appropriate menu-driven control for each module. For

instance, once the module icon is selected using the switch panel 1208 or encoder 1214 of the GCI module 1032, the GCI module 1032 automatically displays a menu screen of options on display 1206 associated with the particular module. Once a particular option is selected, another menu screen may be provided to display 1206 giving further options. Button sizes and text fonts are included in the graphics format data stored in the GCI module 1032. The menu structure information provides the actual textural material to be included with the menu-screen buttons.

The GCI module 1032 next updates a menu saved status flag at block 1278. This status flag provides an indication that all the menu structure information for the particular module has been downloaded. GCI module 1032 then proceeds to block 1280 of Fig. 18.

GCI module determines whether this particular loop is the first time through after power up or if a new module has been added as illustrated at block 1280. If not, GCI module 1032 proceeds to block 1286. If it is the first time through or a new module has been added, GCI module 1032 reconfigures an opening menu to include icons of all the modules present as illustrated at block 1282. In other words, the main menu initial display screen of display 1206 is updated to include an icon representing each of the controllable modules. GCI module 1032 then reconfigures existing menus to include the new options of added modules as illustrated at block 1284. The code stored in the GCI module 1032 is altered, in real time, to merge new menu information for the newly added modules with existing menu information of the previous modules.

GCI module 1032 then performs an integrity check on RAM 1232 based saved information as illustrated at block 1286 (i.e., checksum). If the integrity of the stored information in RAM 1232 is not correct at block 1288, GCI module 1032 changes an appropriate saved status flag at

block 1290. GCI module 1032 then proceeds back to block 1268 to download the appropriate graphical format information or menu structure information for the particular module again.

If the integrity of the information saved in RAM 1232 is correct at block 1288, GCI module 1032 determines whether an input switch from switch panel 1208 or encoder 1214 has been pressed at block 1292. If no input has been pressed, GCI module returns to block 1264 of Fig. 17 to perform another system query at the next predetermined time interval.

If an input switch has been pressed at block 1292, GCI module 1032 updates the display screen 1206 as illustrated at block 1294. The GCI module 1032 then transmits an appropriate network command to the particular module to perform any selected application or specific function as illustrated at block 1296. For instance, GCI module 1032 can transmit a signal to scale module 1022 to weigh a patient, to surface instrument module 1024 and air supply module 1014 to adjust the pressure within a particular bladder of the bed surface, or to perform any other module function.

It is understood that the hospital network can use the GCI module 1032 in an identical way to the other network modules. The hospital network can send menu driven control options to the GCI if desired. Either the patient or the caregiver can use the GCI module 1032 to control bed functions and interact with the hospital network or another remote location.

The automated data collection feature of communications module 1020 is illustrated in further detail in Fig. 19. A request for bed information and/or bed control is received as illustrated at block 1300. The request is either from the hospital information network or from a remote data acquisition system. In other words, the

hospital bed may be connected to the hospital network through wiring in a wall as discussed above. In addition, the bed may be connected to another piece of equipment in the room which can be connected to a remote location through the hospital network, a modem, or other data link. Finally, the request for information and/or control can be from an on-board bed data acquisition system..

The particular command or status request is then mapped to a network variable or value as illustrated at block 1302. In other words, the received request or command is changed to a usable network format at block 1302. Illustratively, a table is used to transform the received request for information and/or control to an appropriate and understandable network command.

A message is then issued to the bed modules over the communication network as illustrated at block 1304. Communications module 1020 determines whether the particular module responded over the network with an acknowledgement of the message at block 1306. Once a particular module receives a message, an acknowledgement of the message is transmitted back over the network before the particular function is carried out by the module. If the acknowledgement is not received, the communication module 1020 sets an error status indicator as illustrated at block 1308. If the acknowledgement is received at block 1306, communications module 1020 next determines whether the module responds over the network with a particular status that was requested or with an acknowledgement that a particular control has been implemented as illustrated at block 1310. If not, communications module 1020 sets the error status indicator as illustrated at block 1308. If the module did respond over the network with the particular status requested or with the acknowledgement that the control was implemented, the network response is mapped to the off bed network as illustrated at block 1310. The

communications module 1020 transforms the response received from the bed network format to the off-bed network format for transmission at block 1312. The communications module 1020 then sends the off-bed network command or an error message to the remote network as illustrated at block 1314. An error message sent to the hospital network or other remote location provides an indication that something went wrong with the particular request for status information or control. This request can then be retransmitted. A persistent error message indicates problems with one of the modules. Therefore, corrective action to repair the module can be implemented.

Each of the modules on the hospital bed can store specific status information related to operation and control of the bed or related to the module functions in an internal memory present on each module. For instance, the BACM 1018 can store all bed articulations and positions in a memory of the BACM 1018. In addition, the surface instrument module 1024 can store all surface positions and settings or therapy module usages in memory on the surface instrument module 1024. This information can be retrieved using the automated data collection feature discussed above to indicate patient activity. The standard caregiver interface modules 1028 and 1030 can store all entertainment patient control interactions in memory. These interactions can be retrieved via the automated data collection feature for billing or other monitoring purposes. Each module has a capability of storing all patient interaction with controls on the module. This stored information is available to the GCI module 1032 and to the off bed information system via the automated data collection feature.

As discussed above, the hospital network can retrieve status information through the communications module 1020. In addition, status information can be

retrieved from a remote location through a data link coupled to accessory port module 1016. This status information may be bed status information stored in any of the modules. Each module can store status information related to switch presses, and specific movements, controls, or functions performed by the module.

Another module which can be coupled to the peer-to-peer communication network is a patient status module 1320. This patient status module 1320 is illustrated in Fig. 20. The patient status module 1320 monitors and records vital statistics from the patient received from a selected patient monitoring device 1322. Such body monitors may include, for example, temperature sensors, blood pressure detectors, heart rate monitors, or any other body monitor. Data from these monitors 1322 is stored in memory of the patient status module 1320 and can be transmitted over the network to the hospital network or to a remote location through a data link coupled to accessory port 1016. Patient monitoring devices 1322 are discretely coupled to the patient status module 1320.

Another module coupled to the bed peer-to-peer communication network is a gateway module 1324. The gateway module 1324 provides an interface to the network for an application specific module 1326. Specifically, gateway module 1324 provides echelon network interface circuitry for communicating with the peer-to-peer network of the hospital bed. Gateway module 1324 also includes application specific interface circuitry for communicating with the application specific module 1326 for performing a dedicated function on the bed or elsewhere. Therefore, gateway module 1324 provides a format change for the data so that understandable information and commands are transmitted and received by both the bed network and the application specific module 1326.

Another feature of the present invention is that each of the bed modules can be upgraded over the network using a data link through accessory port 1016 or using communications module 1020. Upgrade information can be transmitted from the remote location to the peer-to-peer network. In other words, a remote location can be used to download new software to all the modules connected to the communication network of the bed. This permits an operator to reprogram the bed modules from a remote location over the peer-to-peer communication network.

Yet another feature of the present invention is that each module is able to perform internal diagnostics. After a module performs its dedicated function, a diagnostic check can be performed to make sure that the module is functioning correctly. If an error is detected, an error message can be transmitted over the network to another module or to a remote location through communications module 1020 or accessory port 1016.

Another module of the present invention is illustrated in Fig. 21. Fig. 21 illustrates an automatic charting module 1330. The automatic charting module 1330 includes an echelon controller 1332 which is a networking microprocessor. Controller 1332 accesses memory 1334. Memory 1334 includes an EEPROM, and EPROM, and a static RAM. Controller 1332 is coupled to a RS-485 transceiver 1336. Transceiver 1336 is coupled to first and second network connectors 1338 and 1340. Module 1330 includes an internal power supply 1342 coupled to a power input. Illustratively, power supply 1342 supplies a +5V supply voltage to controller 1332 on line 1344. Power supply 1342 also supplies power to a bar code interface 1346, a display interface 1348, and a keyboard interface 1350. Display interface 1348 and keyboard interface 1350 are optional elements of charting module 1330.

Bar code interface 1346 receives an input from bar code scanner 1352. An output of bar code interface 1346 is coupled to controller 1332 on line 1354. Controller supplies information to display interface 1348 on line 1356. An output from display interface 1348 is coupled to a suitable display 1358. Keyboard interface 1350 receives an input from a keyboard 1360. An output of keyboard interface 1350 is coupled to controller 1332 by line 1362.

Charting module 1330 provides an apparatus for automatically charting patient information. Bar code scanner 1352 and keyboard 1360 provide input devices for inputting information into charting module 1330. It is understood that any type of input device can be used in connection with the present invention. The patient or caregiver can input information to the network using the bar code scanner 1352 or keyboard 1360. This information can remain locally on the peer-to-peer communication network of the hospital bed. In addition, the information can be sent to the hospital network through transceiver 1336 and communication module 1020 or to another remote location via accessory module 1016.

An output device such as display 1358 is provided to display information to the user. The display 1359 can be a series of LEDS or a display panel, such as a LCD display.

The memory of 1334 of charting module 1330 is loaded in a manner similar to the GCI module 1032 discussed above. Memory 1334 contains code that translates raw bar code scanner information and keyboard input information from keyboard 1360 into specific network commands, either for local on-bed use or for hospital network off-bed use. For instance, the nurse can scan bar codes directly from prescription medicine or input various information into keyboard 1360 related to the patient. This input is used

to generate an internal chart of the medical history of the patient for use on the hospital bed. This chart data can be displayed on display 1358. In addition, this chart can be transmitted over the hospital network or transmitted to a remote location using a data link coupled to accessory port 1016.

It is understood that the GCI module 1032 discussed above may be modified to include an input interface such as bar code interface 1346. The functionality of charting module 1330 is similar to the GCI module 1032 except for the scanning device 1352 and the bar code interface 1346.

Another use of charting module 1330 is for inputting a control sequence used to control a module to perform a dedicated function on the bed. For instance, a doctor can prescribe a certain surface therapy for pulmonary or other type of treatment of the patient on the bed. This treatment prescription can specify a period of time for percussion and vibration therapy or for rotational therapy of the patient on the bed. The prescription can include a specific period of time for the therapy with varying rates of rotation or a varying frequency of percussion and vibration. This specific control sequence or prescription is encoded onto a bar code or other appropriate input scanning device format and scanned or otherwise input into charting module 1330. Charting module 1330 then automatically executes the prescribed control sequence by transmitting appropriate commands at appropriate times through transceiver 1336 to the network and to the selected modules to control the selected modules in the prescribed control sequence.

As discussed above, each of the network modules includes an echelon neuron networking microprocessor or controller. Each of the networking controllers has a unique serial number which is different from the serial

number on any other controller. At manufacturing time, a data base is created to associate each unique serial number with the module type and manufacturing date. Any other desired information related to the particular module may also be stored in the data base. Therefore, the hospital bed of the present invention provides an inventory control feature both in the plant prior to shipment of the beds and in the field at remote customer locations. A diagnostic tool coupled to accessory port module 1016 through a data link or the hospital network coupled to communications module 1020 can instantly query a bed over the peer-to-peer communication network to retrieve the unique serial number associated with all the modules on the network of the bed. Therefore, an operator has access to an instantaneous inventory of all the modules and associated features of a particular bed from a remote location for maintenance, repairs, recalls, upgrades, etc. An operator at a remote location can quickly determine the exact modules on the bed at any time.

The apparatus of the present invention can automatically poll beds at a remote location over the network by providing a query to all modules and retrieving all the serial numbers over the network. Therefore, by using the stored data base, an operator can determine an inventory of all bed modules present in a hospital or other remote location.

Although the invention has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the scope and spirit of the present invention as described and defined in the following claims.

CLAIMS:

1. A bed comprising:

a base frame;

a deck coupled to the base frame for supporting a body;

a peer-to-peer communication network having a plurality of connection points;

a plurality of modules, each module being electrically coupled to a selected connection point of the peer-to-peer communication network, each module being configured to perform a dedicated function during operation of the bed, and each module being configured to communicate over the peer-to-peer communication network with selected other modules.

2. The bed of claim 1, further comprising a control interface module coupled to a selected connection point of the peer-to-peer communication network, the control interface module including means for detecting the addition of a new module to the peer-to-peer communication network and means for controlling operation of the new module.

3. The bed of claim 1, wherein the control interface module includes means for displaying user control options for the new module on a display of the control interface module automatically after the new module is added.

4. The bed of claim 1, further comprising a diagnostic module coupled to a selected connection point of the peer-to-peer communication network, the diagnostic module including means for testing operation of the other modules.

5. The bed of claim 4, wherein the diagnostic module generates a recommended correction upon detection of a problem with the operation of one of the other modules,

the diagnostic module generating a signal to supply the recommended correction to a display.

6. The bed of claim 1, wherein the plurality of modules each include a processor circuit for transmitting information to any other module and for receiving information from any other module over the peer-to-peer communication network.

7. The bed of claim 1, wherein one of the plurality of modules includes means for collecting and storing information related to operation of the modules.

8. The bed of claim 1, wherein one of the plurality of modules is a communication module, the communication module being coupled to a data link to transmit signals received from the other modules to a remote location.

9. The bed of claim 8, wherein the communication module receives signals from the remote location and transmits the signals to a selected module to permit the selected module to perform its dedicated function based on instructions received from the remote location.

10. The bed of claim 1, wherein the plurality of modules control a plurality of bed status variables, and wherein one of the plurality of modules includes means for detecting and storing the bed status variables.

11. The bed of claim 10, wherein said one module includes means for displaying the stored bed status variables.

12. The bed of claim 10, wherein said one module includes means for transmitting the stored bed status variables to a remote location.

13. The bed of claim 1, wherein the plurality of modules each include a controller and a memory for storing code which is executed by the controller, and further comprising means coupled to the communication network for

automatically changing the code stored in the memory of the plurality of modules to upgrade the plurality of modules.

14. The bed of claim 1, wherein one of the modules includes a memory for storing a control sequence for controlling another module coupled to the network, and an interface configured to be coupled to an input device for inputting a prescribed control sequence into the memory, the module transmitting commands over the network based on the stored control sequence.

15. The apparatus of claim 14, wherein the input device is a bar code scanner.

16. An apparatus for performing a function on a bed having a base frame, a deck coupled to the base frame for supporting a body, and a peer-to-peer communication network having a plurality of connection points, the apparatus comprising:

a module having a dedicated function, a connector electrically coupled to the module, the connector being configured to mate with a selected connection point of the peer-to-peer communication network to couple the module to the peer-to-peer communication network, the module also including a controller for transmitting and receiving electrical signals over the peer-to-peer communication network as the module performs its dedicated function.

17. The apparatus of claim 16, wherein the module includes an inlet coupled to a sensor, the sensor providing an input signal to the module indicative of a parameter of the bed.

18. The apparatus of claim 16, wherein the module includes an output coupled to an actuator which is coupled to the bed, the module controlling the actuator to perform the dedicated function.

19. The apparatus of claim 16, wherein the deck is an articulating deck coupled to the base frame, the articulating deck including separate deck sections which

are independently movable relative to the base frame and each other, and at least one actuator coupled to each deck section for moving each deck section, and wherein the module is a bed articulation control module configured to send control signals to the actuators to control movement of the deck sections.

20. The apparatus of claim 16, wherein the module is a position sensing module configured to detect various positions of the deck and to transmit a signal indicative of the position of the deck over the peer-to-peer communication network.

21. The apparatus of claim 16, wherein the module is a communication module, the communication module being coupled to a data link for transmitting information related to operation of the bed to a remote location and for receiving information from the remote location to control operation of the bed.

22. The apparatus of claim 16, wherein the bed includes an inflatable mattress and an air handling unit coupled to the inflatable mattress and to the base frame, and wherein the module includes an air supply module for receiving signals from the peer-to-peer communication network and for supplying control signals to the air handling unit to selectively inflate and deflate the mattress.

23. The apparatus of claim 16, wherein the bed includes a weigh frame for measuring a weight of a body on the bed and for generating an output signal indicative of the weight, the weigh frame supporting the deck, and wherein the module is a scale module for receiving the signal indicative of the weight of the body, the scale module providing an output signal to the peer-to-peer communication network a display.

24. The apparatus of claim 16, wherein the module is a patient status module, the patient status

module being coupled to at least one patient monitoring device, the patient status module storing patient status information and transmitting the patient status information over the network.

25. The apparatus of claim 16, wherein the module is a gateway module, the gateway module being coupled to an application specific module to provide an interface between the application specific module and the peer-to-peer communication network.

26. The apparatus of claim 16, wherein the module is a charting module having an interface configured to be coupled to an input device for inputting patient information into the charting module, the charting module storing the patient information and transmitting the patient information to the communication network.

27. The apparatus of claim 26, wherein the input device is a bar code scanner.

28. A bed comprising:

a base frame;

an articulating deck coupled to the base frame, the articulating deck including separate deck sections that are independently movable relative to the base frame and to each other;

at least one actuator coupled to each deck section for moving the deck section;

a mattress located on the articulating deck for supporting a body;

a peer-to-peer communication network having a plurality of module connection points;

a command module coupled to a first module connection point to provide a desired bed movement signal to the peer-to-peer communication network; and

a bed articulation control module coupled to a second module connection point for peer-to-peer communication with the command module, the bed articulation

control module receiving the signals from the command module and controlling the actuators to move the deck in response to the signals.

29. The bed of claim 28, wherein the actuators include a fluid actuated cylinder, a fluid control unit, and an electrically controlled valve for controlling fluid flow to the cylinders, the bed articulation control module controlling the valve and the fluid control unit.

30. The bed of claim 28, further comprising a position sensing module coupled to a third connection point of the peer-to-peer communication network, the position sensing module supplying signals to the bed articulation control module indicative of the position of each of the deck sections.

31. The bed of claim 30, further comprising a position sensor coupled to each deck section of the articulating deck, each position sensor being coupled to the position sensing module.

32. The bed of claim 31, wherein each position sensor detects the position of the deck section relative to gravity.

33. The bed of claim 28, wherein said command module includes a user input panel to permit a user to control the position of the articulating deck sections.

34. The bed of claim 28, wherein said command module is coupled to a side rail of the bed.

35. The bed of claim 28, further comprising a communication module coupled to a third connection point of the peer-to-peer communication network for peer-to-peer communication with the other modules, the communication module being coupled to a data link to transmit signals from the communication module to a remote location and to receive signals from the remote location.

36. The bed of claim 28, wherein said mattress is inflatable, the bed further comprising an air handling

unit coupled to the mattress and to the base frame and a surface control module coupled to a third connection point of the peer-to-peer communication network for peer-to-peer communication with the other modules, said surface control module receiving commands from said command module and controlling the air handling unit to inflate and deflate the mattress selectively.

37. The bed of claim 36, wherein the articulating deck includes a head section, a foot section, and a thigh section movable to a chair configuration, and wherein the surface control module is configured to deflate a foot section of the mattress upon receiving a signal from the network to move the articulating deck to the chair configuration.

38. The bed of claim 37, wherein the deck includes a foot panel adjacent the foot section, the foot panel being movable from an extended position to a retracted position as the articulating deck moves to the chair configuration, the bed articulation control module controlling movement of an actuator coupled to the foot panel to retract the foot panel when the bed articulation control module receives a signal from the command module designating movement of the articulating deck to the chair position.

39. The bed of claim 28, further comprising:

a weigh frame for measuring a weight of a body on the articulating deck and generating a signal indicative of the weight, the weigh frame supporting the articulating deck;

a scale module coupled to a third connection point of the peer-to-peer communication network for peer-to-peer communication with the other modules, said scale instrument receiving said signal indicative of the weight from the weigh frame; and

a visual display connected to the scale module, said visual display displaying a visual representation of the weight.

40. The bed of claim 28, further comprising:

a weigh frame for measuring a weight of a body on the articulating deck and for generating a signal indicative of the weight, the weigh frame supporting the articulating deck;

a scale module coupled to a third connection point of the peer-to-peer communication network for peer-to-peer communication with the other modules, said scale instrument receiving the signal indicative of the weight from the weigh frame; and

a communication module coupled to a fourth connection point of the peer-to-peer communication network for peer-to-peer communication with the other modules, the communication module being coupled to a data link to transmit signals from the bed to a remote location, the communication module receiving said signal indicative of the weight from the scale module and transmitting the signal indicative of the weight to the remote location.

41. The bed of claim 28, further comprising a graphical caregiver interface module coupled to a third connection point of the peer-to-peer communication network for peer-to-peer communication with the other modules, the graphical caregiver interface module including a display and a user input to permit interactive menu driven communication with the other modules.

42. The bed of claim 28, further comprising a diagnostic tool module coupled to a third connection point of the peer-to-peer communication network for peer-to-peer communication with the other modules, the diagnostic tool module being configured to test operation of at least one of the other modules.

43. The bed of claim 42, wherein the diagnostic tool module includes a data link connection coupled to the third connection point to permit the diagnostic test on the other modules to be conducted from a remote location via the data link connection.

44. The bed of claim 28, wherein the bed movement command module includes a lockout switch to provide a lockout indicator signal to the bed articulation control module and prevent movement of the articulating deck, and a separate lockout enabling switch spaced apart from the lockout switch, the command module requiring both the lockout enabling switch and the lockout switch to be activated in order to change a lockout status of the command module.

45. The bed of claim 44, wherein said command module is located in a siderail of the bed, the siderail being located near a head section of the articulating deck.

46. The bed of claim 28, wherein the bed articulation control module includes a pulse width modulation controller coupled to the actuators.

47. The bed of claim 28, wherein at least two actuators are provided for moving the deck section, and wherein the bed articulation control module generates at least two time periods for controlling the actuators, the bed articulation control module permitting only one actuator to be controlled during each time period to minimize power usage.

48. The bed of claim 28, wherein the bed includes a plurality of actuators, and a separate electrically controlled solenoid for each of the actuators, the bed articulation control module establishing a plurality of different time periods for controlling the solenoids, the bed articulation control module controlling only one solenoid during each time period in order to reduce power consumption.

49. The bed of claim 28, wherein the bed articulation control module includes a memory for storing the signals received from the command module, the bed articulation control module transmitting the stored signals to the communication network.

50. A bed comprising:

a base frame;

an articulating deck coupled to the base frame, the articulating deck including separate deck sections that are independently movable relative to the base frame and to each other;

at least one actuator coupled to each deck section for moving the deck section;

a mattress located on the articulating deck for supporting a body;

a peer-to-peer communication network having a plurality of module connection points;

a graphic caregiver interface module coupled to a first module connection point of the network, the graphic caregiver interface module including an input device, a control circuit coupled to the network and to the input device, the control circuit including means for transmitting control signals over the network, a memory coupled to the control circuit for storing predetermined graphic format data, and a display coupled to the control circuit; and

a bed articulation control module coupled to a second module connection point for peer-to-peer communication with the command module, the bed articulation control module receiving the control signals from the control circuit and controlling the actuators to move the deck in response to the control signals.

51. The bed of claim 50, wherein said mattress is inflatable, the bed further comprising an air handling unit coupled to the mattress and to the base frame and a

surface control module coupled to a third connection point of the peer-to-peer communication network for peer-to-peer communication with the other modules, said surface control module receiving control signals from said control circuit and controlling the air handling unit to inflate and deflate the mattress selectively.

52. The bed of claim 50, further comprising a weigh frame for measuring a weight of a body on the articulating deck and generating a signal indicative of the weight, the weigh frame supporting the articulating deck, a scale module coupled to a third connection point of the peer-to-peer communication network for peer-to-peer communication with the other modules, said scale instrument receiving said signal indicative of the weight from the weigh frame, and the scale module using the display of the graphical caregiver interface module to display a visual representation of the weight.

53. An apparatus for controlling operation of a module coupled to a communication network of a bed to perform a dedicated function on a bed, the apparatus comprising:

an input device;

a control circuit coupled to the network in communication with the module, the control circuit also being coupled to the input device, the control circuit including means for detecting that the module is coupled to the network and for transmitting control signals to the module based on an signal input from the input device;

a memory coupled to the control circuit for storing predetermined graphic format data; and

a display coupled to the control circuit, the control circuit receiving commands from the module to retrieve stored graphic format data from the memory and to output the graphic format data on the display to provide a menu-driven control for the module using the input device.

54. The apparatus of claim 53, further comprising a communication module coupled to the communication network and to a hospital network to permit the hospital network to use the display.

55. The apparatus of claim 53, therein the module is configured to supply information for use with a particular graphic format to the control circuit, the control circuit including means for detecting whether the particular graphic format data is stored in the memory and means for downloading the particular graphic format data from the module to the memory if the particular format data is not present in the memory.

56. The apparatus of claim 55, therein the particular graphic format data is downloaded into the memory automatically when the module is added to the network.

57. A method for permitting a module which is configured to perform a dedicated function on a bed and which is coupled to a communication network on the bed to use a graphical interface having an input device, a control circuit coupled to the network and to the input device, a memory coupled to the control circuit, and a display coupled to the control circuit, the method comprising the steps of:

storing predetermined graphic format data in the memory of the control circuit;

determining whether the particular graphic format data used by the module is stored in the memory;

downloading the particular graphic format data from the module into the memory if the particular graphic format data is not stored in the memory; and

using the stored particular graphic format to drive the display based on information transmitted from the module over the network.

58. The method of claim 57, wherein the downloading step occurs automatically when the module is added to the network.

59. A lockout control apparatus for disabling a selected function on a bed having a base frame, a deck coupled to the base frame for supporting a body, and a controller for controlling bed functions, the apparatus comprising:

at least one lockout switch, the lockout switch having a first state to transmit a signal to the controller to disable the selected function, and a second state to permit the controller to perform the selected function; and

a global enable switch coupled to the controller, the global enable switch having a first state to permit actuation of the at least one lockout switch and a second state to disable the at least on lockout switch.

60. The apparatus of claim 59, wherein the at least one lockout switch and the global enable switch are located in a siderail coupled to the bed.

61. The apparatus of claim 59, wherein the deck is an articulating deck coupled to the base frame, the articulating deck including separate head, knee, and foot deck sections which are independently movable relative to the base frame and to each other, the apparatus including a separate lockout switch for the head, knee, and foot sections, and wherein the global enable switch controls activation of the head lockout switch, the knee lockout switch, and the foot lockout switch.

62. The apparatus of claim 59, wherein the global enable switch remains in the first state for a predetermined time interval and then automatically changes to the second state if a lockout switch is not actuated by a user during the predetermined time interval.

63. The apparatus of claim 59, wherein the at least one lockout switch controls both patient functions and caregiver functions on the bed.

64. A method for monitoring a plurality of modules configured to perform dedicated functions on a hospital bed, the modules being coupled to an electrical communication network on the bed, each module having a controller for communicating over the network, the method comprising the steps of:

assigning a unique serial number to the controller of each of the modules;

recording each unique serial number and an associated module type;

retrieving all the unique serial numbers for the controllers of modules coupled to the network of a bed; and

determining the type of modules on the bed using the retrieved unique serial numbers and the recorded information.

65. A bed comprising:

a base frame;

a deck coupled to the base frame for supporting a body;

a communication network;

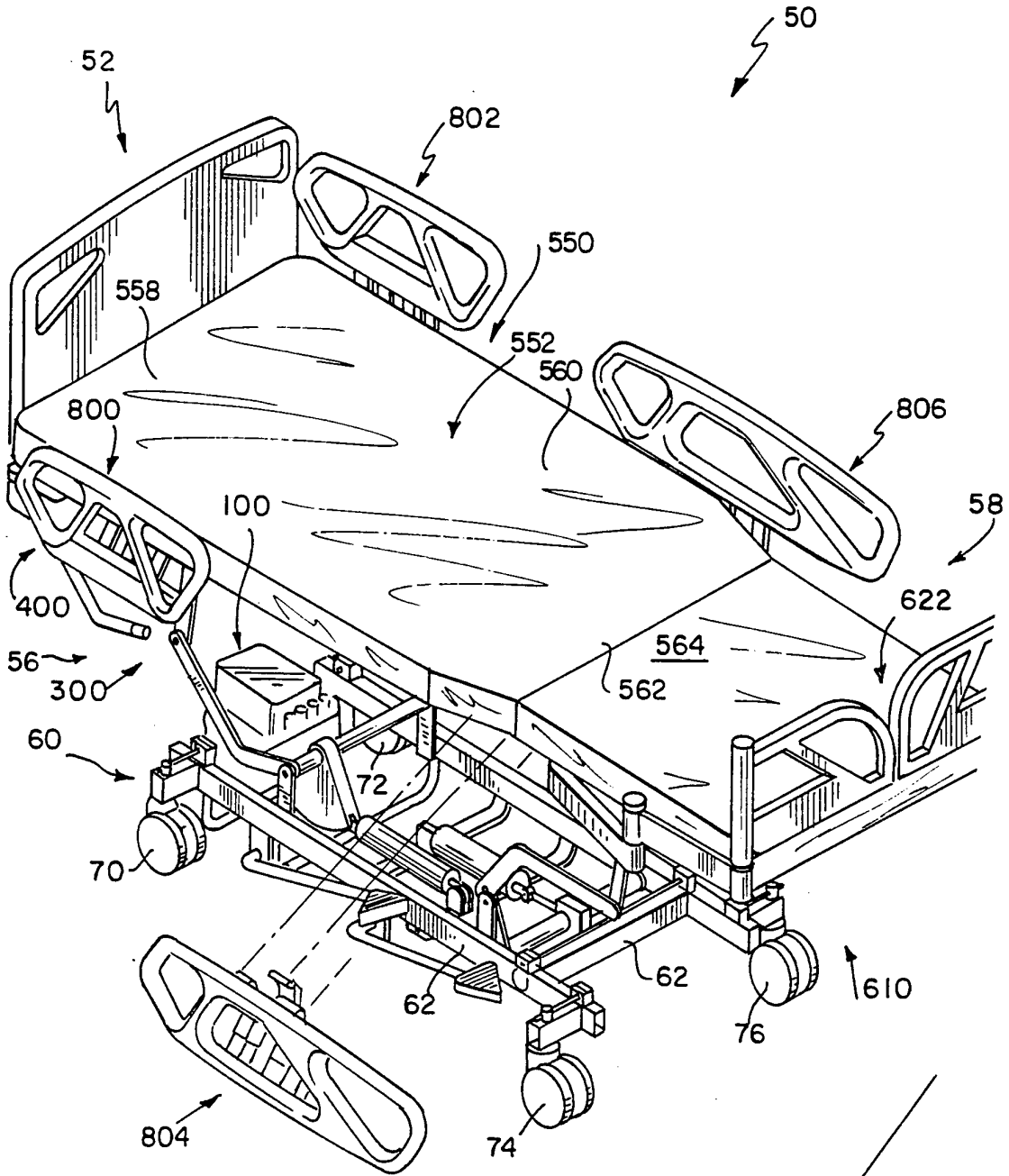
a plurality of modules coupled to the communication network, each module being configured to perform a dedicated function during operation of the bed, each module including a controller for communicating over the communication network, each controller having an assigned unique serial number; and

means coupled to the communication network for retrieving the unique serial numbers of the controllers of the plurality of modules to provide an indication of the types of modules coupled to the network.

66. The bed of claim 65, wherein the retrieving means includes a communications module coupled to the

network for transmitting the unique serial numbers to a remote location through a data link.

67. The bed of claim 66, wherein the communications module permits an operator from a remote location to inventory the modules coupled to the communication network of the bed.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74

FIG. 1

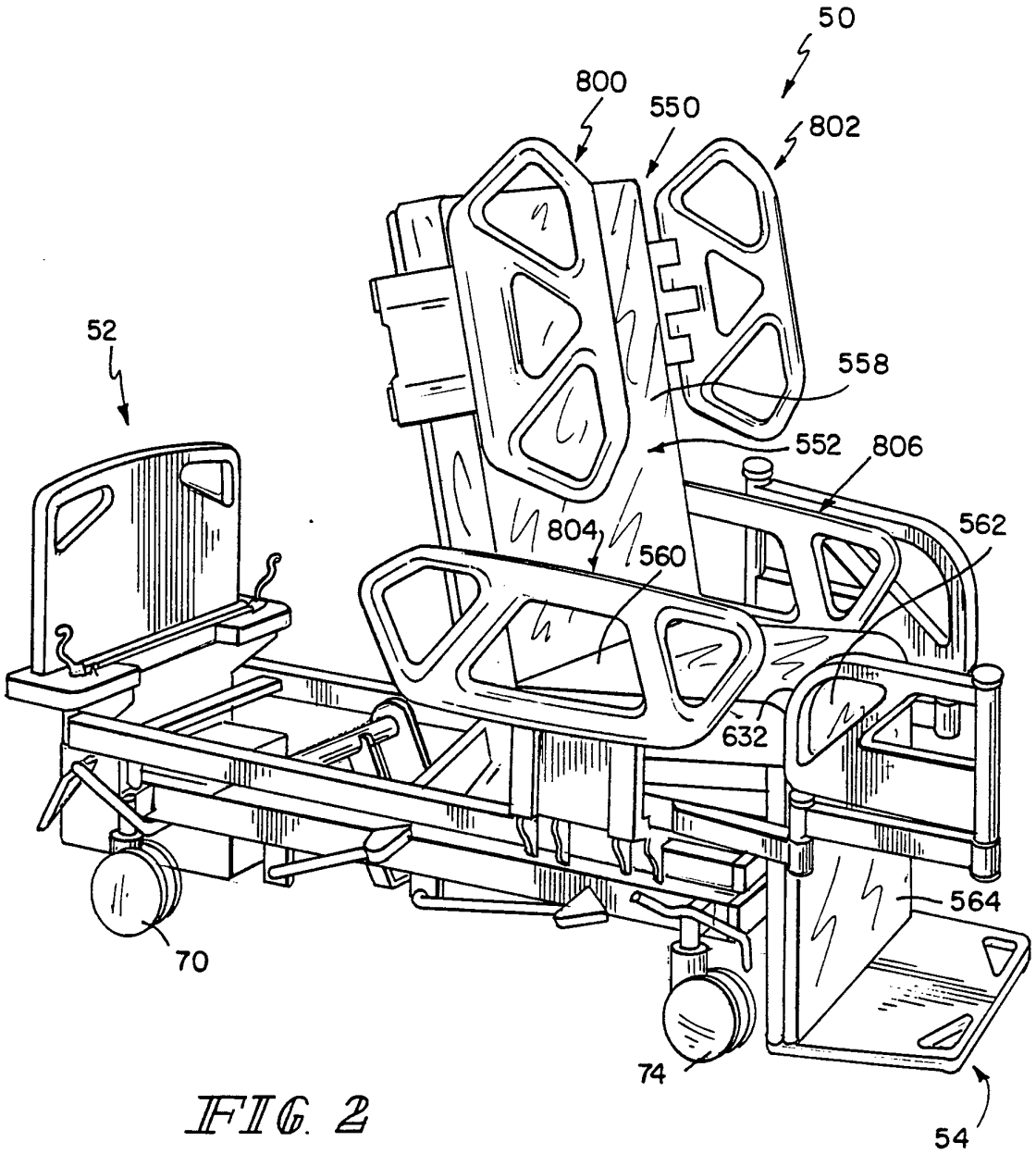


FIG. 2

FIG. 3

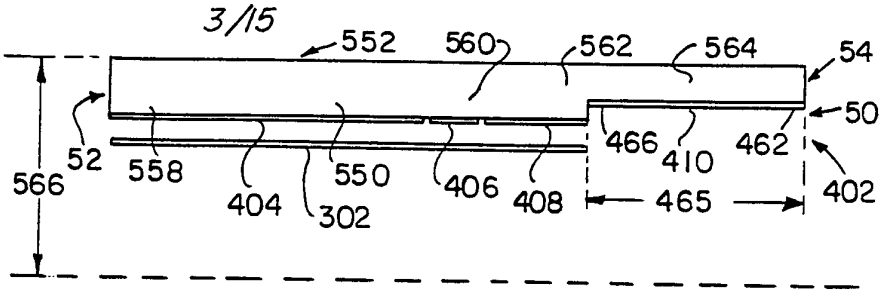


FIG. 4

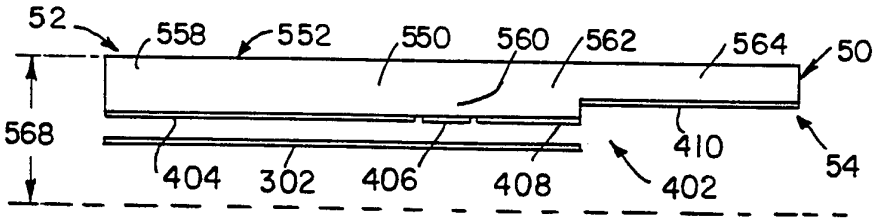


FIG. 5

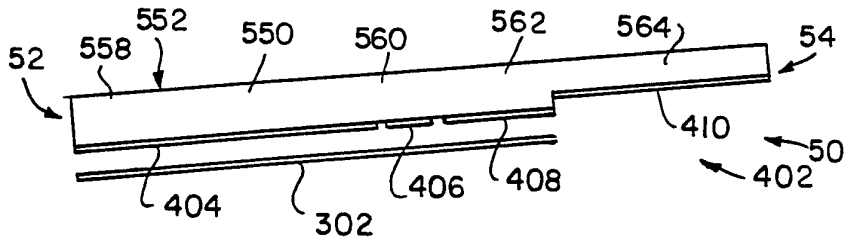


FIG. 6

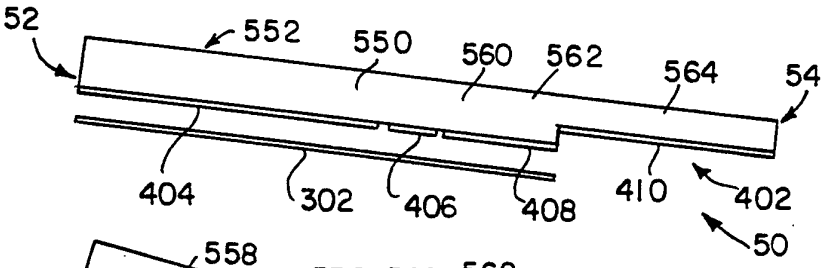


FIG. 7

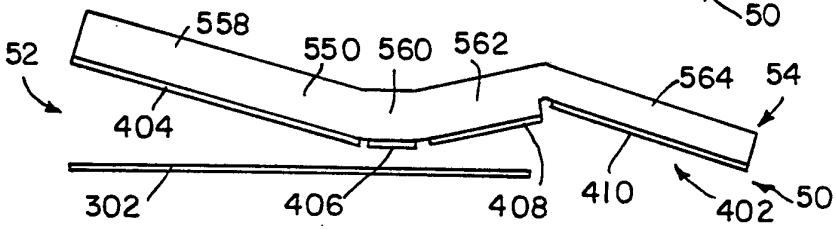
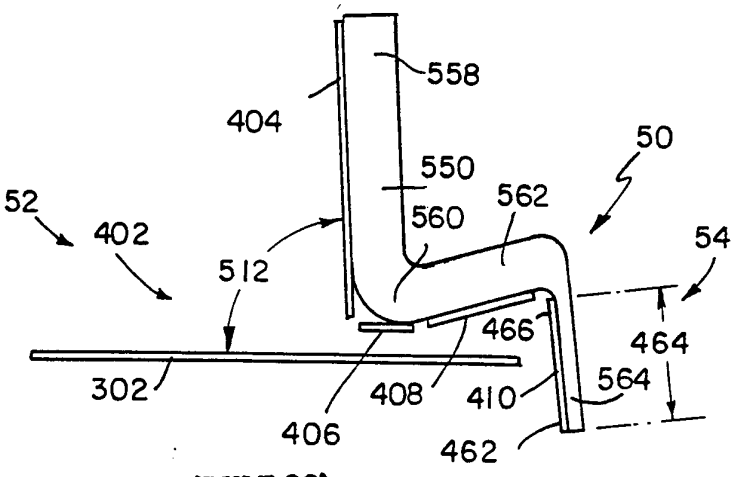


FIG. 8



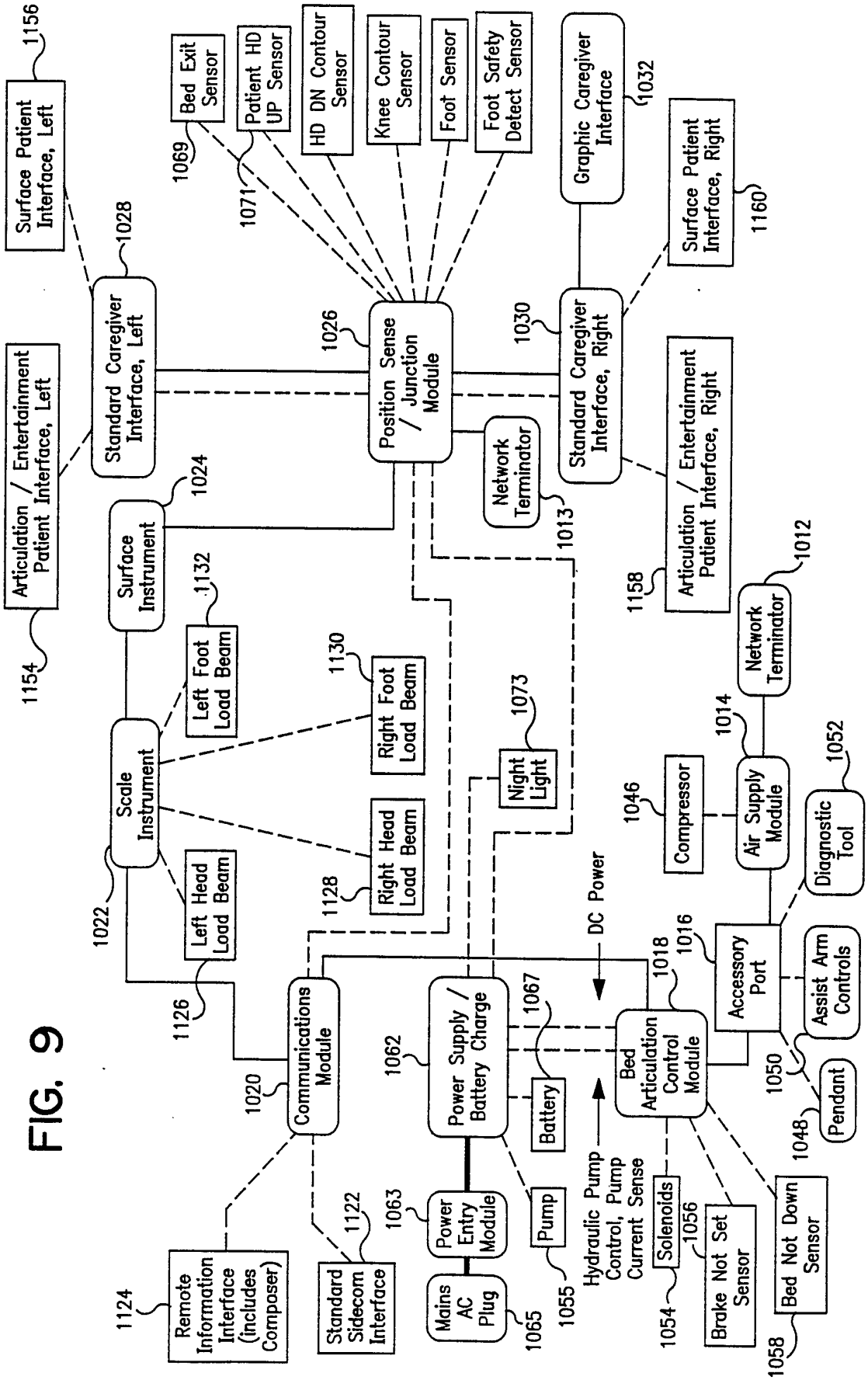

Surface Patient Interface, Left
1156
Articulation / Entertainment Patient Interface, Left
1154
Standard Caregiver Interface, Left
1028
Bed Exit Sensor
1069
Patient HD UP Sensor
1071
HD DN Contour Sensor
Knee Contour Sensor
Foot Sensor
Foot Safety Detect Sensor
Graphic Caregiver Interface
1032
Surface Patient Interface, Right
1160
Position Sense / Junction Module
1026
Standard Caregiver Interface, Right
1030
Network Terminator
1013
Articulation / Entertainment Patient Interface, Right
1158
Surface Instrument
1024
Left Foot Load Beam
1132
Right Foot Load Beam
1130
Scale Instrument
1022
Left Head Load Beam
1126
Right Head Load Beam
1128
Night Light
1073
Network Terminator
1012
Compressor
1046
Air Supply Module
1014
Diagnostic Tool
1052
DC Power
Communications Module
1020
Power Supply / Battery Charge
1062
1067
Battery
Bed Articulation Control Module
1018
Accessory Port
1016
Assist Arm Controls
Pendant
1048
1050
Hydraulic Pump Control, Pump Current Sense
Pump
1055
Solenoids
1054
Brake Not Set Sensor
1056
Bed Not Down Sensor
1058
Power Entry Module
1063
Mains AC Plug
1065
Standard Sidecom Interface
1122
Remote Information Interface (includes Composer)
1124

FIG. 9

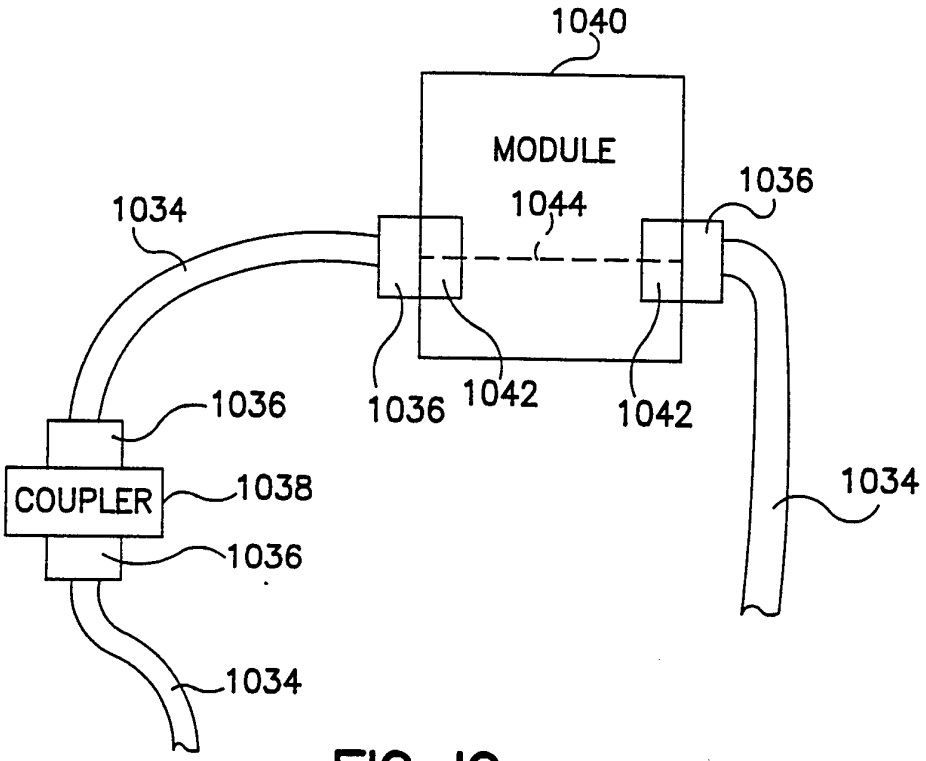

1040
MODULE
1044
1036
1034
1036
1042
1036
1042
1036
COUPLER
1038
1036
1034
1034

FIG. 10

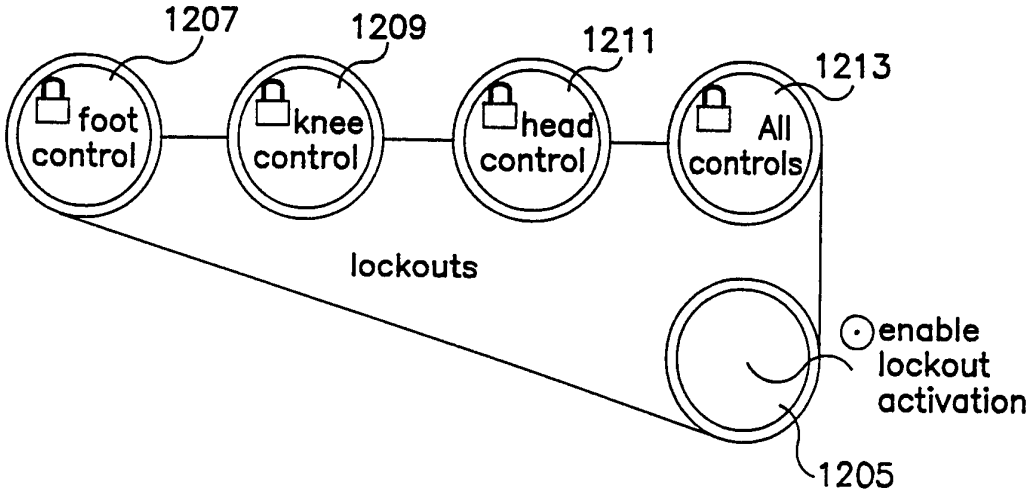

1207
1209
1211
1213
foot control
knee control
head control
All controls
lockouts
enable lockout activation
1205

FIG. 15

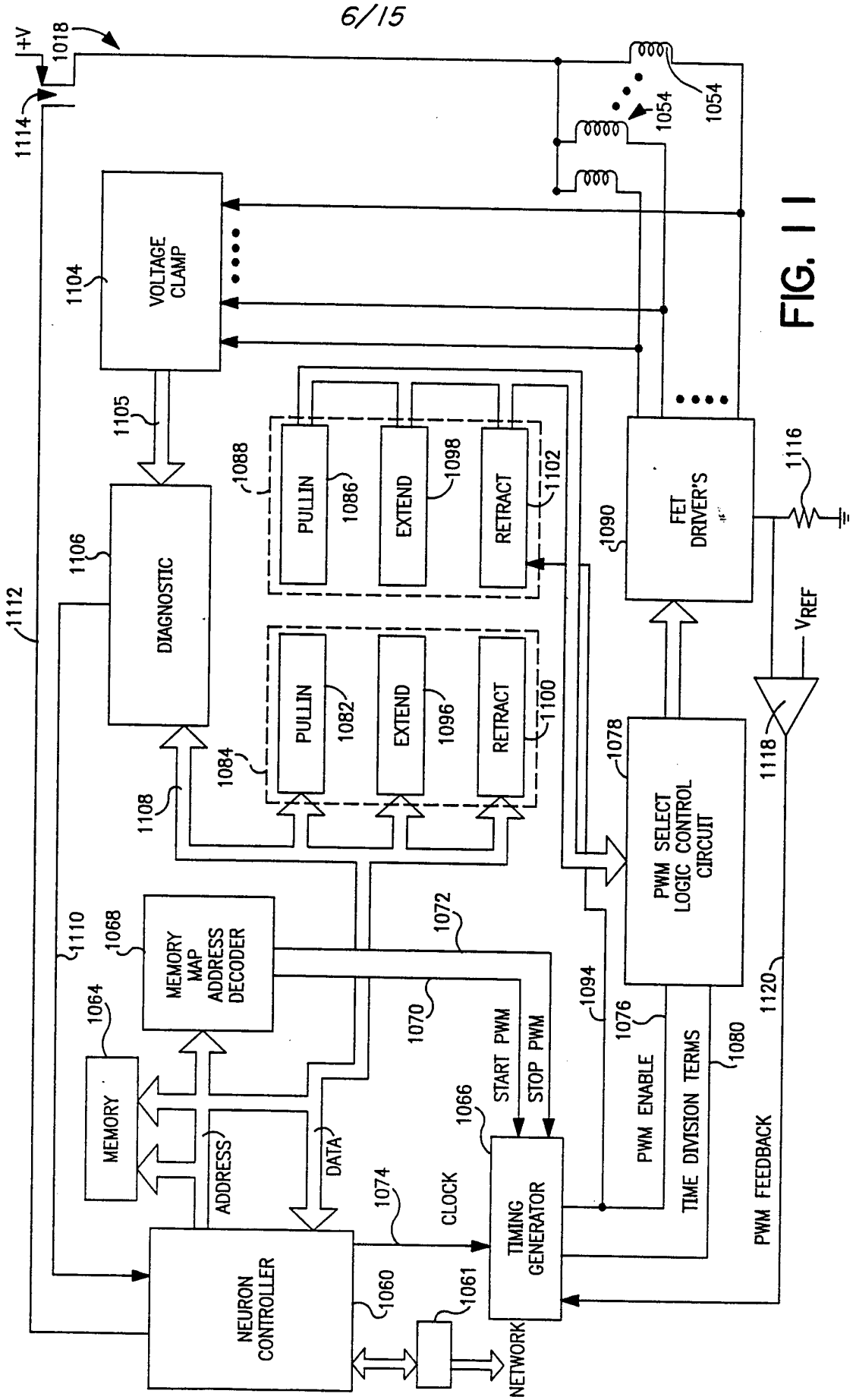

+V
1018
1114
1054
1054
VOLTAGE CLAMP
1104
1105
1088
PULLIN
1086
EXTEND
1098
RETRACT
1102
FET DRIVER'S
1090
1116
1106
DIAGNOSTIC
1112
V_{REF}
PULLIN
1082
EXTEND
1096
RETRACT
1100
1084
1078
1118
1108
PWM SELECT LOGIC CONTROL CIRCUIT
1110
1068
MEMORY MAP ADDRESS DECODER
1072
1064
1070
1094
1120
1076
1080
MEMORY
START PWM
STOP PWM
PWM ENABLE
TIME DIVISION TERMS
1066
ADDRESS
DATA
1074
CLOCK
TIMING GENERATOR
PWM FEEDBACK
NEURON CONTROLLER
1060
1061
NETWORK

FIG. 11

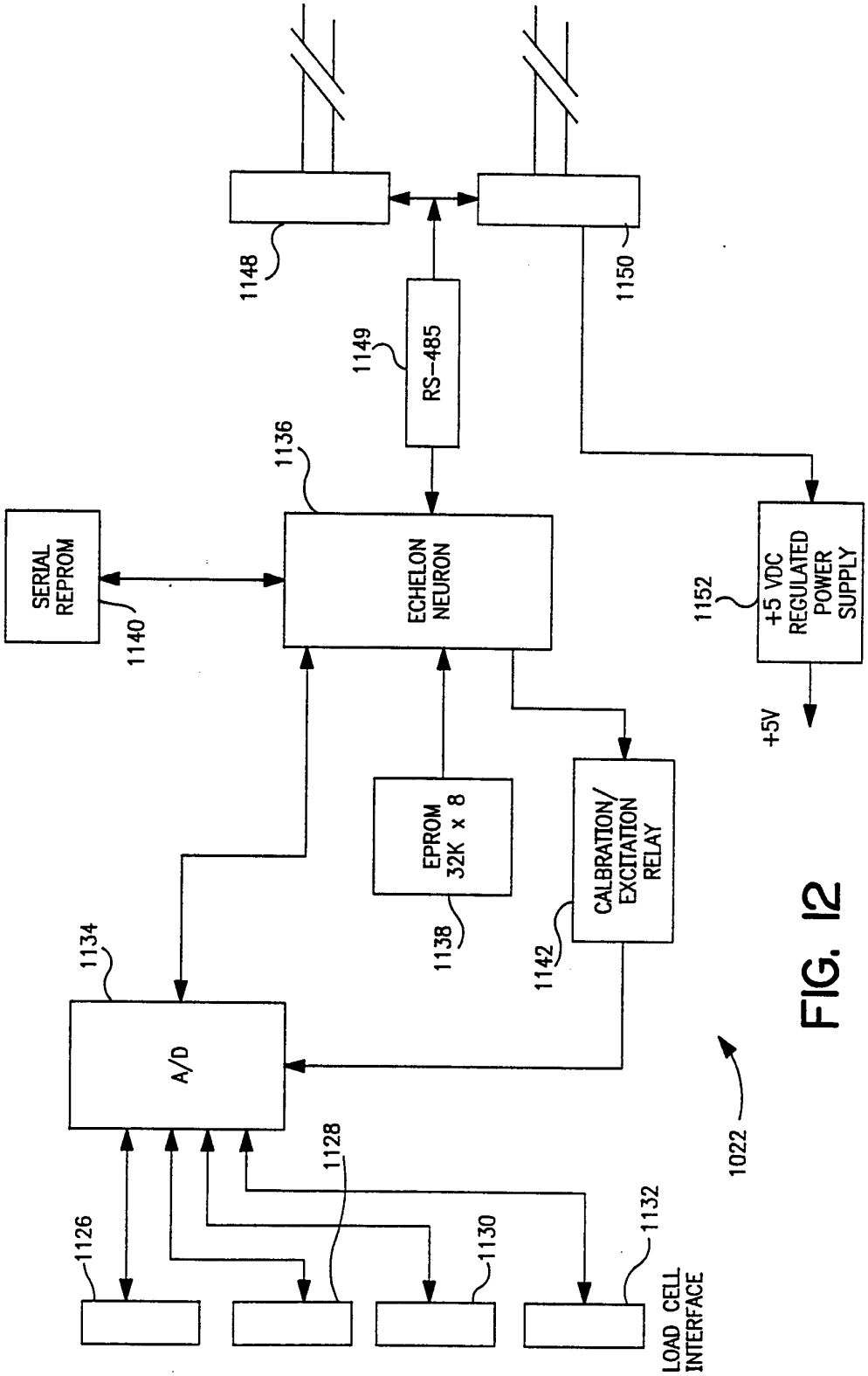

1148
1150
1149
RS-485
1136
SERIAL REPROM
1140
ECHELON NEURON
1152
+5 VDC REGULATED POWER SUPPLY
+5V
EPROM 32K x 8
1138
CALBRATION/ EXCITATION RELAY
1142
1134
A/D
1022
1128
1126
1130
1132
LOAD CELL INTERFACE

FIG. 12

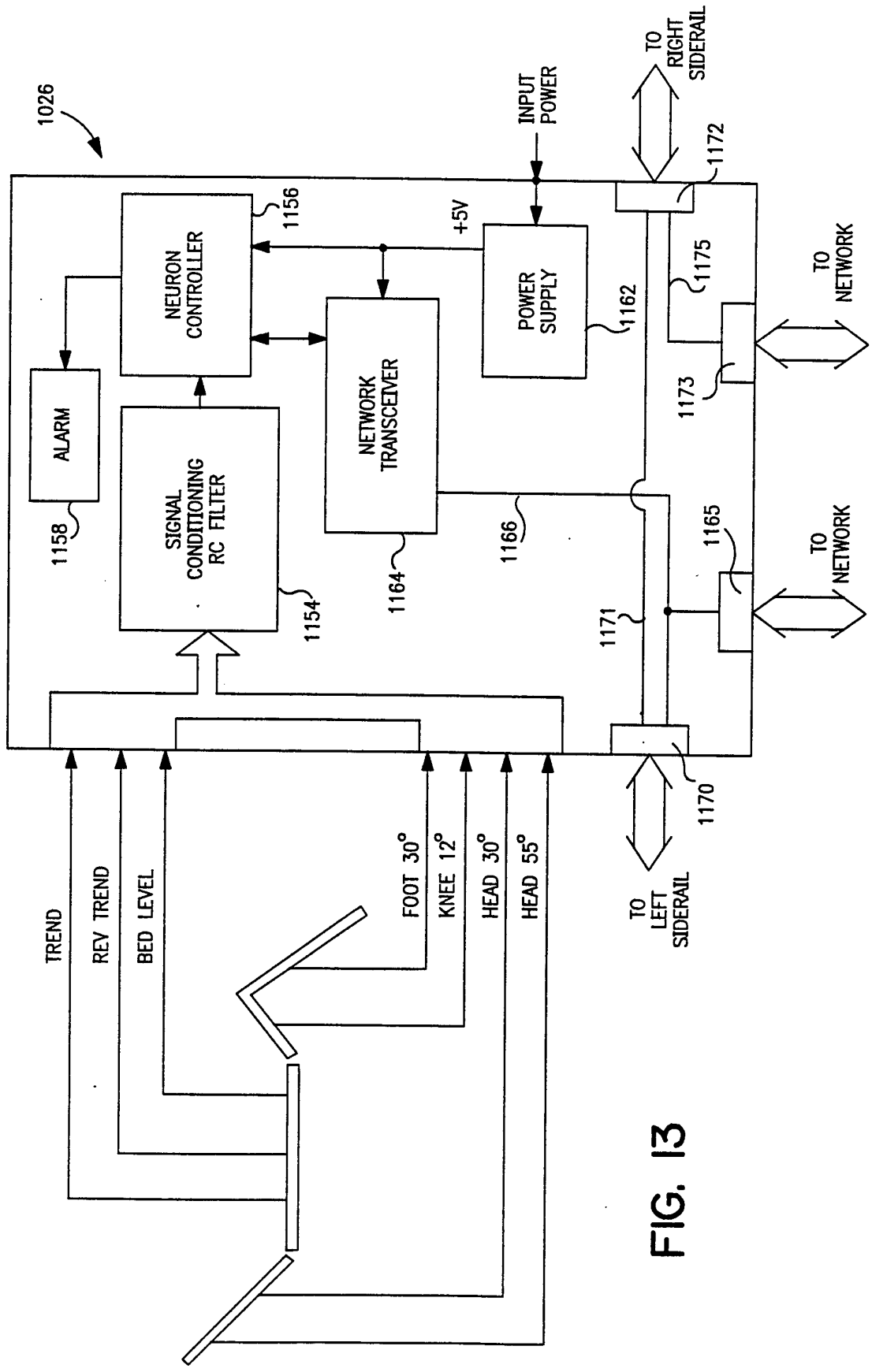

1026
INPUT POWER
TO RIGHT SIDERAIL
1172
1156
NEURON CONTROLLER
+5V
POWER SUPPLY
1162
1175
TO NETWORK
ALARM
NETWORK TRANSCEIVER
1173
1158
SIGNAL CONDITIONING RC FILTER
1166
1165
1164
1154
1171
TO NETWORK
1170
TO LEFT SIDERAIL
TREND
REV TREND
BED LEVEL
FOOT 30°
KNEE 12°
HEAD 30°
HEAD 55°

FIG. 13

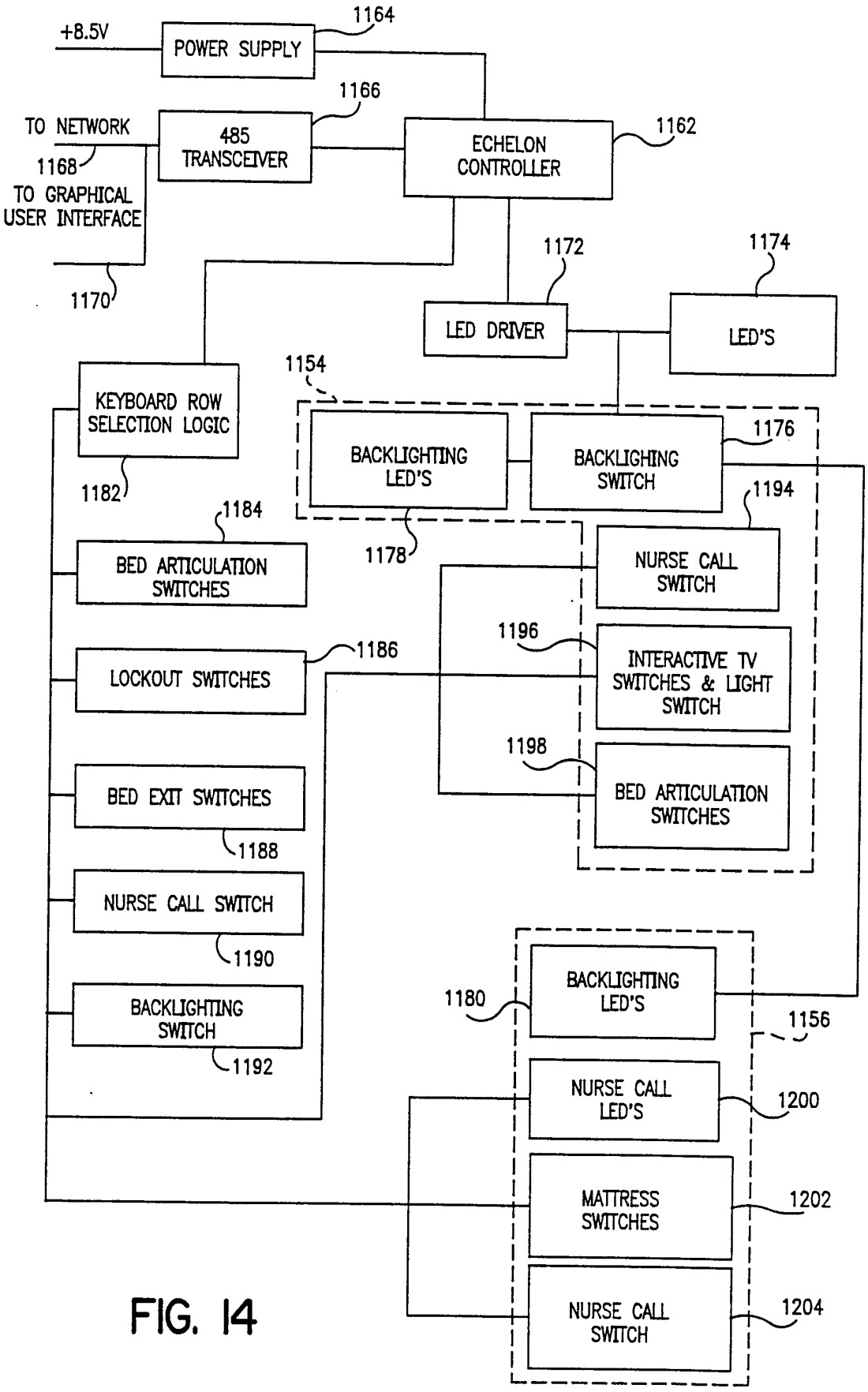

+8.5V
POWER SUPPLY
1164
TO NETWORK
1168
TO GRAPHICAL USER INTERFACE
1170
485 TRANSCEIVER
1166
ECHELON CONTROLLER
1162
1172
LED DRIVER
1174
LED'S
KEYBOARD ROW SELECTION LOGIC
1182
1154
BACKLIGHTING LED'S
BACKLIGHING SWITCH
1176
1178
1194
NURSE CALL SWITCH
1184
BED ARTICULATION SWITCHES
1196
INTERACTIVE TV SWITCHES & LIGHT SWITCH
1186
LOCKOUT SWITCHES
1198
BED ARTICULATION SWITCHES
BED EXIT SWITCHES
1188
NURSE CALL SWITCH
1190
BACKLIGHTING SWITCH
1192
1180
BACKLIGHTING LED'S
1156
NURSE CALL LED'S
1200
MATTRESS SWITCHES
1202
NURSE CALL SWITCH
1204

FIG. 14

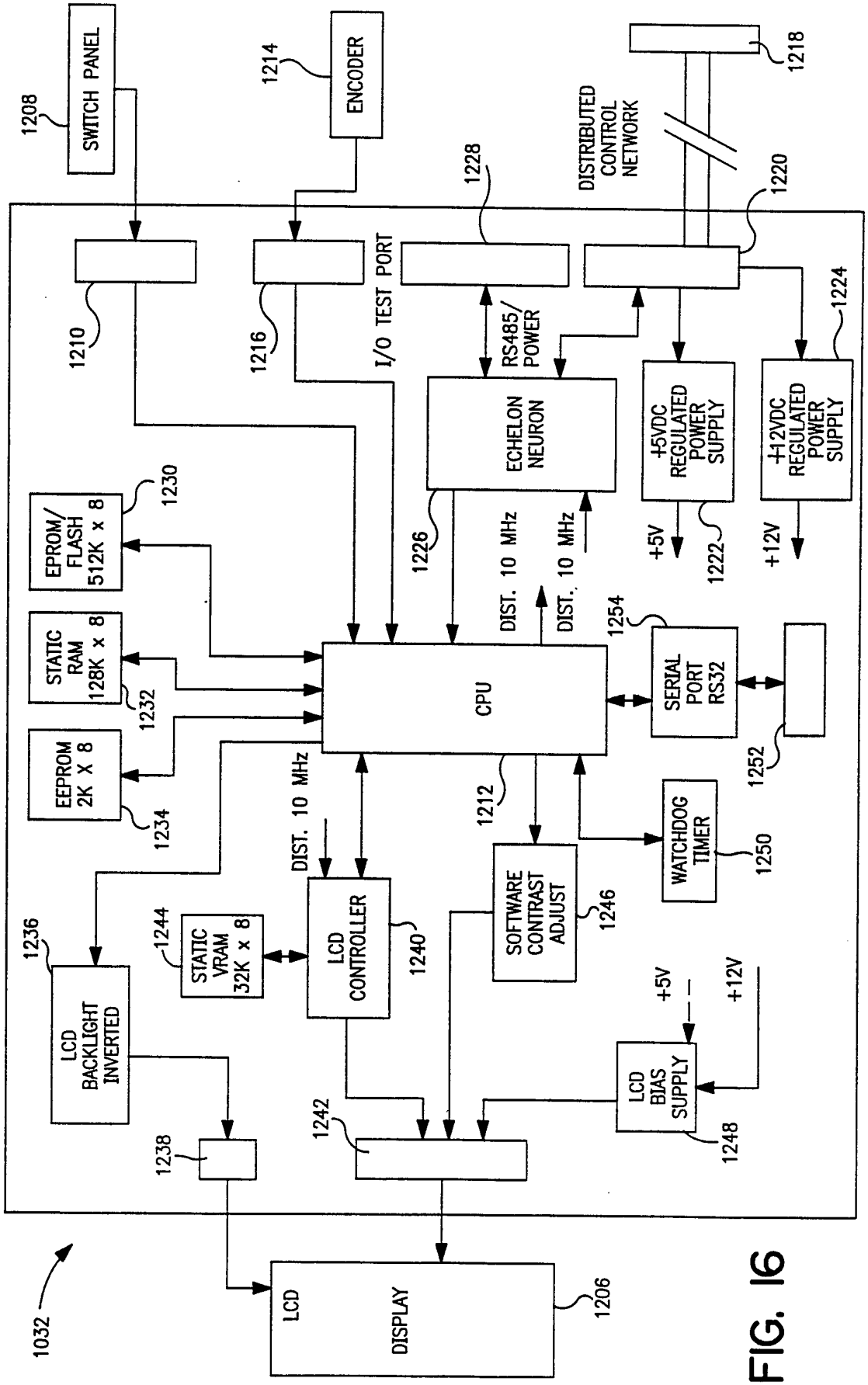
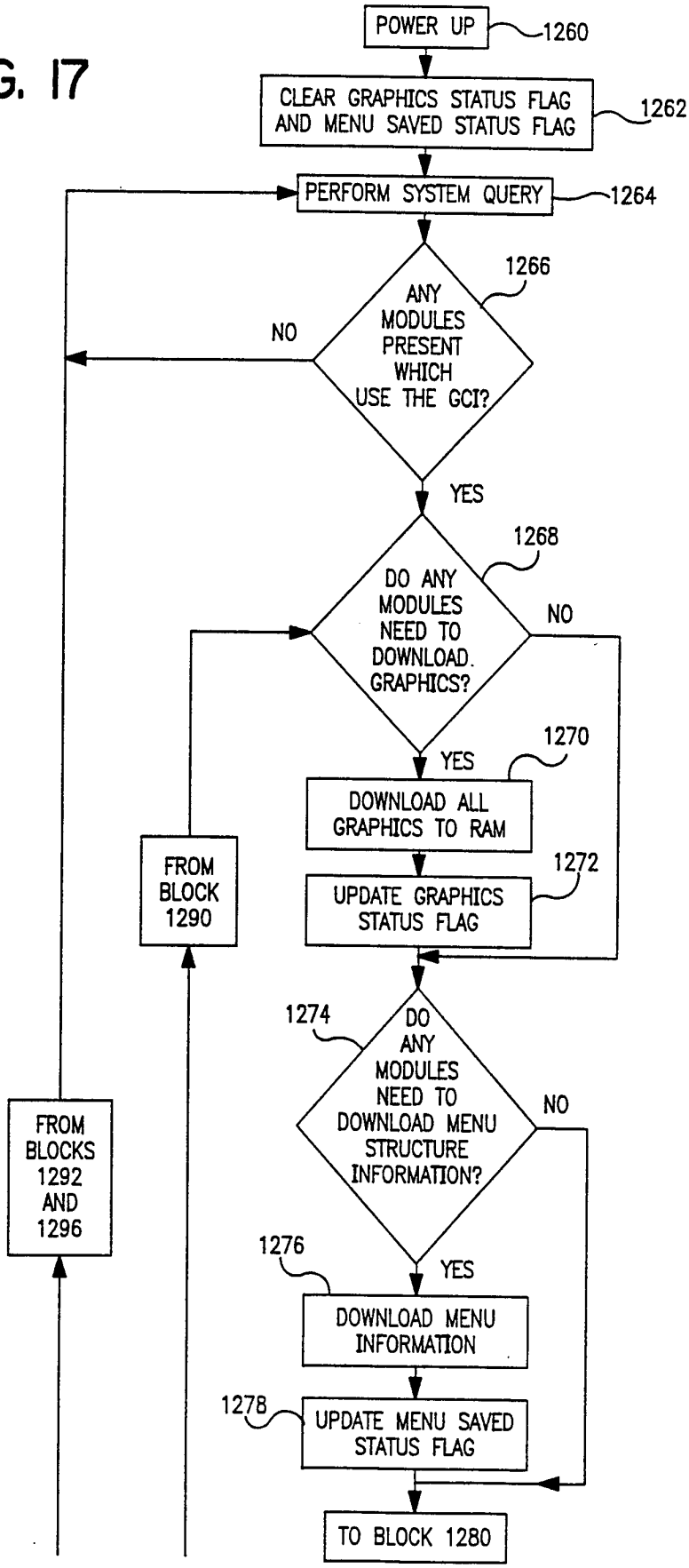

1032
1208
SWITCH PANEL
1214
ENCODER
1218
DISTRIBUTED CONTROL NETWORK
1228
1220
1210
1216
I/O TEST PORT
RS485/ POWER
1224
ECHELON NEURON
+5VDC REGULATED POWER SUPPLY
+12VDC REGULATED POWER SUPPLY
1230
EPROM/ FLASH 512K x 8
1226
DIST. 10 MHz
DIST. 10 MHz
+5V
1222
+12V
1254
STATIC RAM 128K x 8
1232
CPU
SERIAL PORT RS32
1252
EEPROM 2K X 8
1234
1212
DIST. 10 MHz
WATCHDOG TIMER
1250
1236
1244
STATIC VRAM 32K x 8
LCD CONTROLLER
1240
SOFTWARE CONTRAST ADJUST
1246
+5V
+12V
LCD BACKLIGHT INVERTED
LCD BIAS SUPPLY
1238
1242
1248
LCD DISPLAY
1206

FIG. 16

FIG. 17


POWER UP
1260
CLEAR GRAPHICS STATUS FLAG AND MENU SAVED STATUS FLAG
1262
PERFORM SYSTEM QUERY
1264
1266
ANY MODULES PRESENT WHICH USE THE GCI?
NO
YES
1268
DO ANY MODULES NEED TO DOWNLOAD GRAPHICS?
NO
YES
1270
DOWNLOAD ALL GRAPHICS TO RAM
1272
UPDATE GRAPHICS STATUS FLAG
FROM BLOCK 1290
1274
DO ANY MODULES NEED TO DOWNLOAD MENU STRUCTURE INFORMATION?
NO
YES
1276
DOWNLOAD MENU INFORMATION
1278
UPDATE MENU SAVED STATUS FLAG
FROM BLOCKS 1292 AND 1296
TO BLOCK 1280

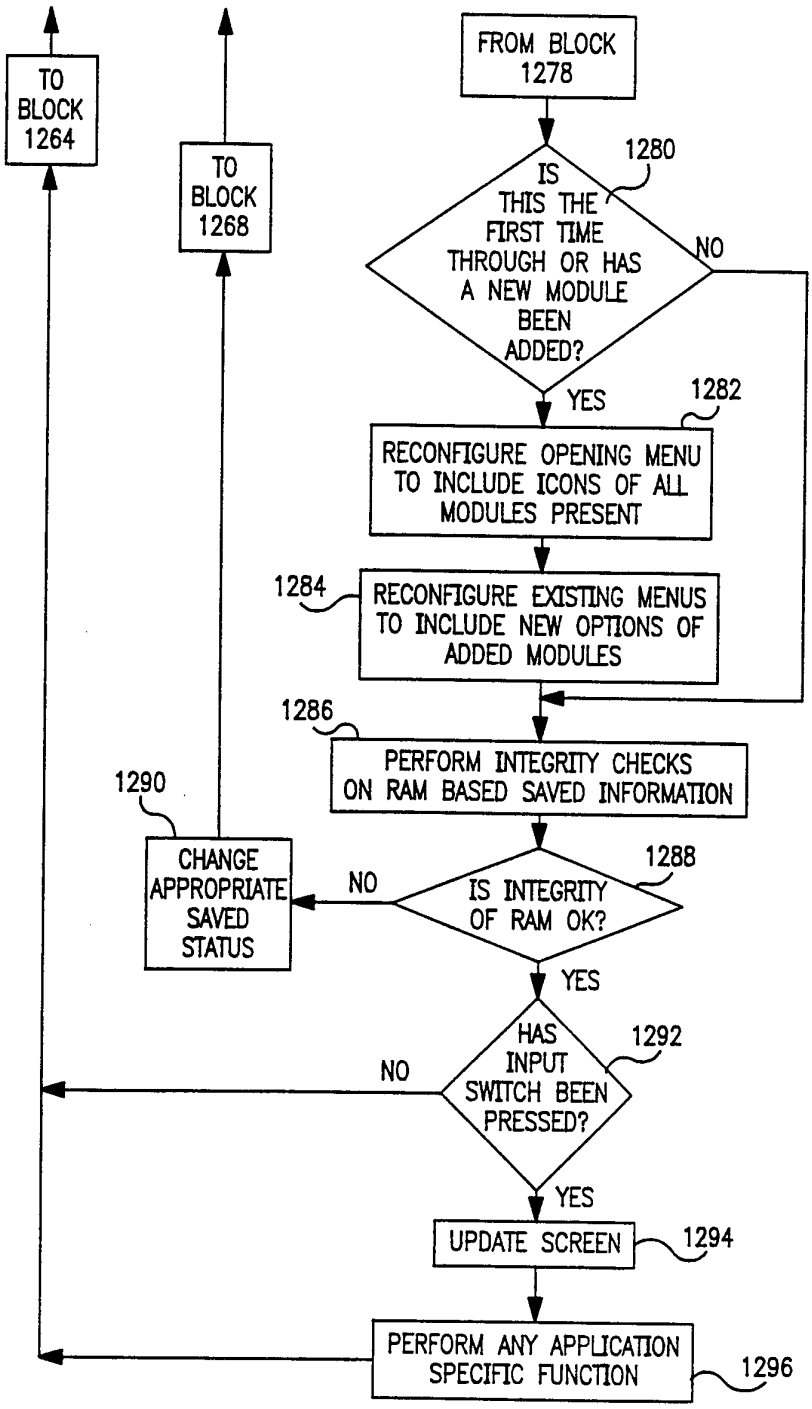

TO BLOCK 1264
TO BLOCK 1268
FROM BLOCK 1278
1280
IS THIS THE FIRST TIME THROUGH OR HAS A NEW MODULE BEEN ADDED?
NO
YES
1282
RECONFIGURE OPENING MENU TO INCLUDE ICONS OF ALL MODULES PRESENT
1284
RECONFIGURE EXISTING MENUS TO INCLUDE NEW OPTIONS OF ADDED MODULES
1286
PERFORM INTEGRITY CHECKS ON RAM BASED SAVED INFORMATION
1290
CHANGE APPROPRIATE SAVED STATUS
NO
1288
IS INTEGRITY OF RAM OK?
YES
HAS INPUT SWITCH BEEN PRESSED?
1292
NO
YES
UPDATE SCREEN
1294
PERFORM ANY APPLICATION SPECIFIC FUNCTION
1296

FIG. 18

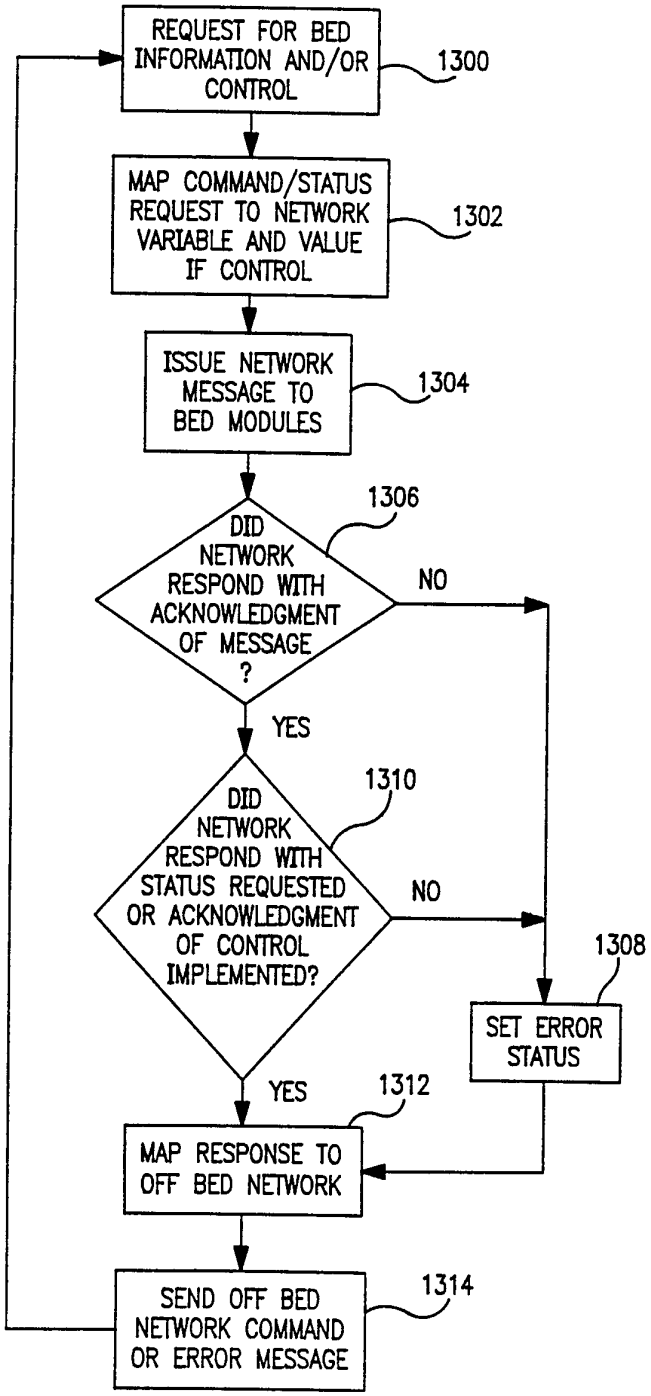

REQUEST FOR BED INFORMATION AND/OR CONTROL
1300
MAP COMMAND/STATUS REQUEST TO NETWORK VARIABLE AND VALUE IF CONTROL
1302
ISSUE NETWORK MESSAGE TO BED MODULES
1304
DID NETWORK RESPOND WITH ACKNOWLEDGMENT OF MESSAGE ?
1306
NO
YES
DID NETWORK RESPOND WITH STATUS REQUESTED OR ACKNOWLEDGMENT OF CONTROL IMPLEMENTED?
1310
NO
1308
SET ERROR STATUS
YES
1312
MAP RESPONSE TO OFF BED NETWORK
SEND OFF BED NETWORK COMMAND OR ERROR MESSAGE
1314

FIG. 19

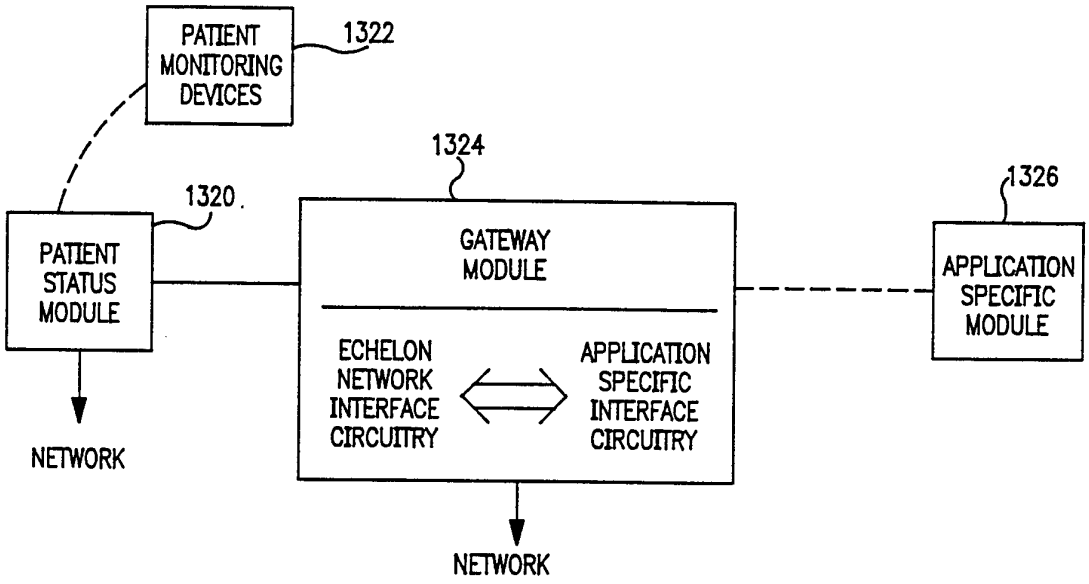

PATIENT MONITORING DEVICES
1322
1324
1320
1326
PATIENT STATUS MODULE
GATEWAY MODULE
APPLICATION SPECIFIC MODULE
ECHELON NETWORK INTERFACE CIRCUITRY
APPLICATION SPECIFIC INTERFACE CIRCUITRY
NETWORK
NETWORK

FIG. 20

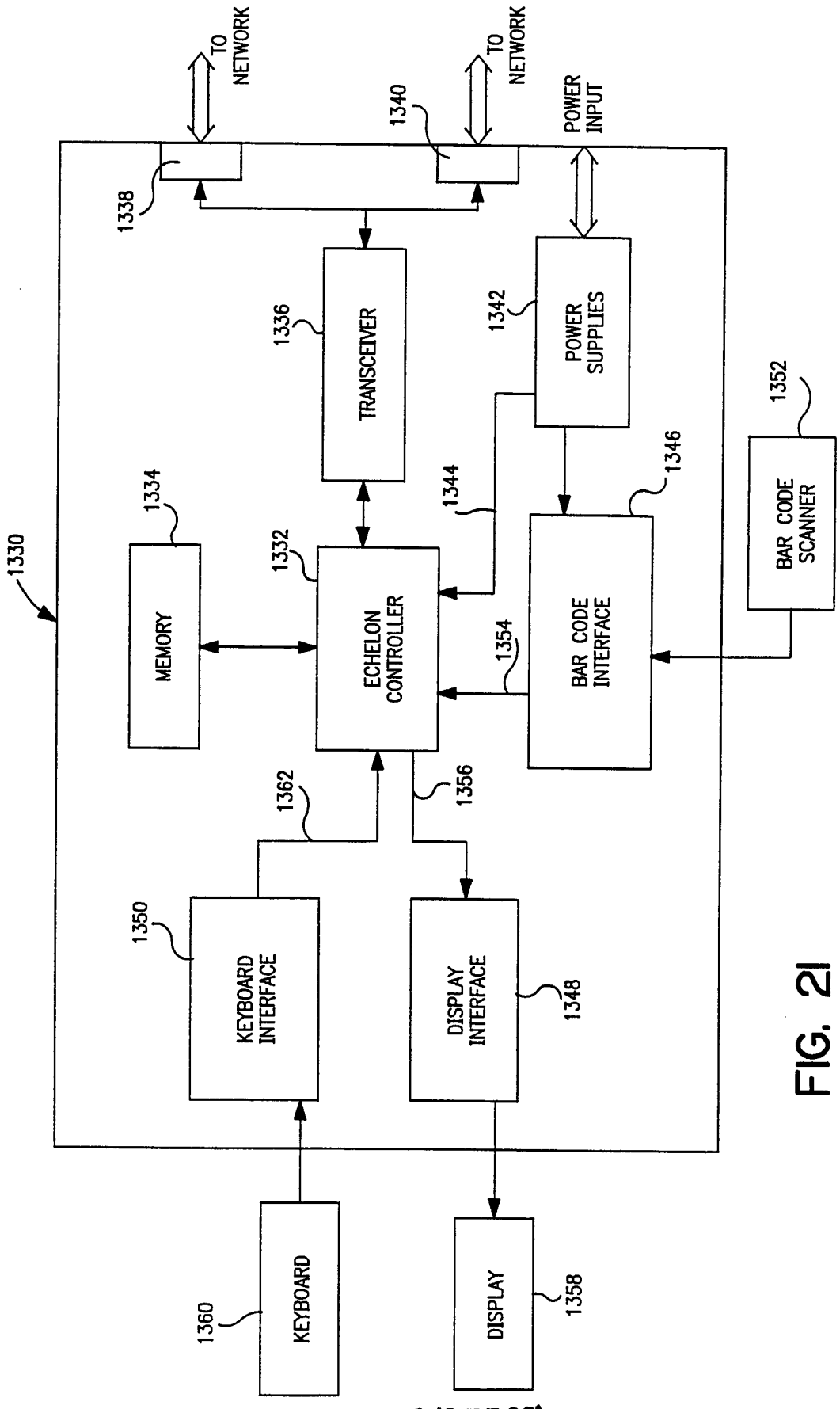

TO NETWORK
TO NETWORK
POWER INPUT
1340
1338
1336
TRANSCEIVER
1342
POWER SUPPLIES
1352
BAR CODE SCANNER
1346
1344
1334
1330
1332
MEMORY
ECHELON CONTROLLER
1354
BAR CODE INTERFACE
1362
1356
1350
KEYBOARD INTERFACE
DISPLAY INTERFACE
1348
1360
KEYBOARD
DISPLAY
1358

FIG. 21

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/12214

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A61G 7/00
US CL :5/600, 610, 624, 507.1, 602
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 5/600, 610, 624, 507.1, 602; 340/825.52, 825.06, 825.050; 128/630

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,279,010 A(FERRAND ET AL) 18 January 1994 (18/01/94) see entire document, especially columns 8-16, line 1-68.	1-56 and 65-67
Y	US 4,638,313 A (SHERWOOD ET AL) 20 JANUARY 1987 (20/01/87), see entire document, especially column 1, line 145-68.	1-58, and 64-67
Y	US 4,800,384 A (SNIJDERS) 24 JANUARY 1989 (24/01/89), see entire document, especially column 2-3, line 11-68 & 1-40	4-5, 42-45, and 59-63
Y	US 5,361,755 A (SCHRAAG ET AL) 08 November 1994 (08/11/94) , see entire document, especially column 3, lines 7-63.	14-15, 27, and 53-56

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search
16 OCTOBER 1996

Date of mailing of the international search report
07 NOV 1996

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
FREDRICK C. CONLEY
Telephone No. (703) 308-3868

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/12214

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/12214

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim(s) 1-56 and 65-67, drawn to a bed.

Group II, claim(s) 57-58 and 64, drawn to a method for controlling modules in a communication network.

Group III, claim(s) 59-63, drawn to a control mechanism.

The inventions listed as Groups II and III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The different inventions of a method for controlling modules in a communication network and a control mechanism other than the disclosed use in the bed are independent since they are not connected in design, operation, or effect thereby having different functions.

The inventions listed as Groups I and II do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The inventions are related as product and process of use. The inventions can be shown to be distinct if either or both of the following can be shown: (1) the process for using the product as claimed can be practiced with another materially different product or (2) the product as claimed can be used in a materially different process of using that product. In the instant case, the method can be used in a patient monitoring system.

The inventions listed as Groups I and III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The different inventions of a bed and a control mechanism other than the disclosed use in the bed are independent since they are not connected in design, operation, or effect thereby having different functions.