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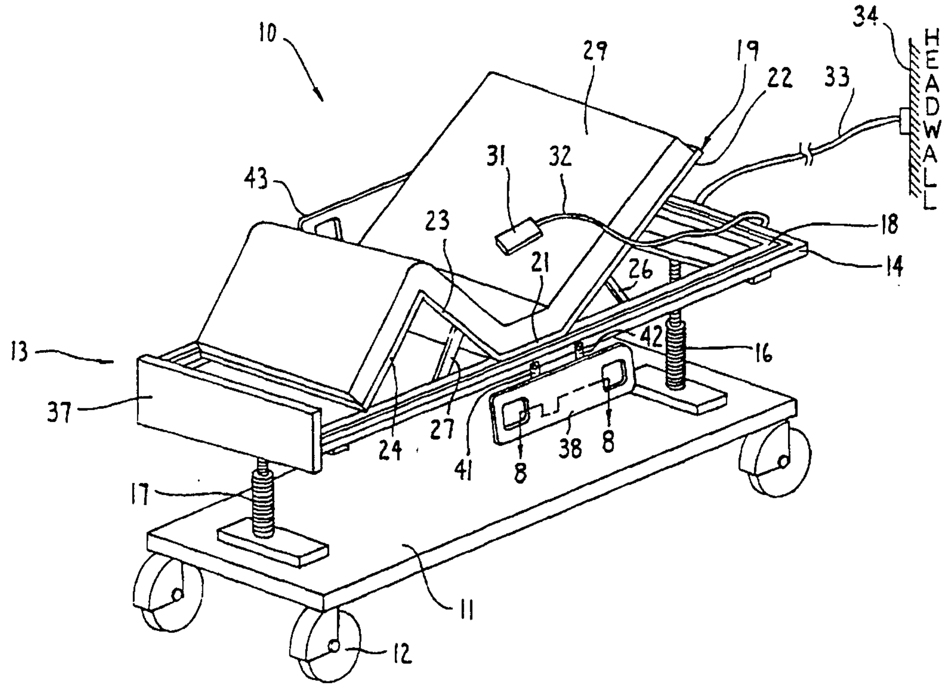
(54) Title: HOSPITAL BED HAVING SERIAL COMMUNICATION NETWORK, DIGITAL VOLUME CONTROL, AND EASILY PERSONALIZED HEADWALL INTERFACE

(57) Abstract



A hospital bed (10) has a frame (14, 18) carrying a patient support section (19) and a footboard (37), and two siderails (38, 43) are supported on the frame for movement between raised and lowered positions. The siderails and footboard each have an operator interface (76-80, 88-89) which includes push-button switches and LEDs, and a serial communication link (56-57, 63-64) couples each operator interface to a control circuit (51) mounted on the frame. Each operator interface includes multiple circuit boards (76-80, 88-89) which represent respective function groups and which each can be either present or omitted in dependence on whether its function group is needed. One such board (76) can control an auxiliary device separate from the bed, such as an inflatable mattress (29) with an electrically-controlled pressure. The control circuit (51) is coupled to a headwall interface circuit (62), which in turn is coupled through a socket/header arrangement (233) to a headwall cable connector on the bed. By changing the headers (291-292) in the sockets (286-287), the interconnections between the connector and the interface circuit can be customized for particular applications. The interface circuit (62) includes a digital volume control circuit (261-264, 271-279) for controlling the amplitude of an audio signal supplied to loudspeakers (68-69) provided in the siderails.

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HOSPITAL BED HAVING SERIAL COMMUNICATION NETWORK, DIGITAL VOLUME CONTROL, AND EASILY PERSONALIZED HEADWALL INTERFACE

FIELD OF THE INVENTION

The present invention relates to a hospital bed and, more particularly, to a bed having a serial communication network, a digital volume control arrangement, and an easily personalized headwall interface.

BACKGROUND OF THE INVENTION

In recent years, the use of electrically-controlled components or sub-systems on hospital beds has been increasing. For example, there are existing commercial beds in which the patient litter is supported by weight sensors commonly known as load cells, and in which a microprocessor-based control circuit is responsive to the load cells for monitoring the weight of the patient, and for detecting patient exit from the bed (for example when the entire weight of the patient suddenly disappears from the readings from the load cells). Various other comparable sub-systems already exist, and others will certainly be developed over the next few years. Some of these sub-systems can be controlled in whole or in part by the patient, and it is common to provide manually operable switches or the like on one or both siderails of the bed to facilitate patient control of the sub-system.

Since sub-systems of this type are often relatively expensive, it is desirable to be able to provide them as an option, so that a sub-system can be omitted to reduce the cost of the bed in a situation where the sub-system is not needed. Where the sub-system is provided, the traditional approach is to run additional wires to each location on the bed where switches or other elements to control the sub-system are to be provided. The cost of the additional wiring, as well as the additional labor required to install it, can be significant.

Accordingly, one object of the invention is to provide a wiring arrangement which permits the addition of optional sub-systems or functions with little or no additional wiring. It is a further object to provide such an arrangement in which even standard systems and functions can be handled with fewer wires than has conventionally been the case.

A further consideration is that the hospital room in which such a bed is used typically has on the wall a connector which is known as the headwall connector and which is coupled to a remote nurse's station and to devices in the hospital room such as the television, room lights and reading lights. A cable is provided to connect the headwall connector to a connector on the bed. Although the signals commonly found at a headwall connector are reasonably standard, the configuration of the headwall connector or the arrangement of signals on it may differ from hospital to hospital. Thus, it is usually necessary to manufacture a set of custom cables for each hospital in order to properly connect the signals at each headwall connector to the corresponding signals in the control circuit of the bed.

Fabrication of custom cables can be relatively expensive and, since cables fail from time to time due to the flexing inherent to normal use, it is necessary to either inventory additional custom cables or to retain detailed information regarding the specific configuration of the cable so that accurate replacements can be fabricated when needed. In this regard, if a hospital owns two or more types of beds which are made by different manufacturers, and if each type of bed requires its own custom cable, it will be recognized that the cost, inconvenience, and confusion can increase, especially when hospital personnel are attempting to install one type of bed in a room and the cable on hand is for the other type of bed. While there may be some situations where custom cables are a satisfactory approach, there are others where an alternative approach is desirable.

Thus, a further object of the invention is to provide a hospital bed which can be internally configured or personalized to conform to the headwall connectors and/or existing beds of a specified hospital, so that a single standard cable can be used for all beds in the hospital, regardless of whether the beds are made by the same manufacturer or by different manufacturers.

SUMMARY OF THE INVENTION

The objects and purposes of the invention, including those set forth above, are met according to one form of the invention by providing an apparatus which includes a bed having a control circuit, an operator interface portion at a location on the bed spaced from the control circuit and having an operator interface element, and an arrangement defining a serial communication link between the operator interface portion and the control circuit.

A different form of the invention involves the provision of a bed having a control circuit, an operator interface portion which is at a location spaced from the control circuit and which includes a first circuit board and a second circuit board, the first circuit board having thereon an interface circuit and the second circuit board being removably remounted on the bed and having thereon an operator interface element which is detachably electrically coupled to the interface circuit on the first circuit board, and an arrangement defining a communication link between the control circuit and interface circuit.

Still another form of the invention involves the provision of a bed having a control circuit with a plurality of first terminals, a headwall connector with a plurality of second terminals, and a removable jumper arrangement for electrically coupling the first terminals to respective second terminals according to a predetermined pattern.

Another form of the invention involves the provision of a bed having a control circuit with a digital volume control output, an audio sound generating element, and an arrangement responsive to an audio signal and to the digital volume control output for supplying the audio signal to the sound generating element with an amplitude which varies as a function of the digital volume control output.

A different form of the present invention involves the provision of a bed having a control circuit, an operator interface element electrically coupled to the control circuit, a light-emitting element, and a light-directing optical element which is adjacent the light-emitting element and which illuminates the operator interface element with light emitted by the light-emitting element.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention is described in detail hereinafter with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic perspective view of a hospital bed embodying the present invention;

Figure 2, and associated Figures 2A, 2B and 2C, show a block diagram of an electrical control circuit for the hospital bed of Figure 1;

Figure 3 is a circuit diagram showing in greater detail a portion of the circuit of Figure 2;

Figure 4, and associated Figures 4A, 4B and 4C, depict a circuit diagram showing in greater detail a different portion of the circuit of Figure 2;

Figure 5, including Figures 5A, 5B, 5C and 5D, depict a circuit diagram showing in greater detail yet another portion of the circuit of Figure 2;

Figure 6 is a diagrammatic view of a socket and header section which is part of the circuit of Figure 5;

Figure 7 is a circuit diagram showing in greater detail still another portion of the circuit of Figure 2; and

Figure 8 is a fragmentary sectional view of one of the siderails of the bed, taken along the line 8-8 in Figure 1;

DETAILED DESCRIPTION

Figure 1 is a diagrammatic perspective view of a hospital bed 10 which embodies the present invention. The bed includes a base 11 movably supported by four casters 12, and a litter section 13 which has an outer frame 14 vertically movably supported by conventional motor-driven head and foot lifts 16 and 17. An inner frame 18 is supported on the outer frame 14 in a conventional manner by four load cells which are not visible in Figure 1, each load cell being located in the region of a respective corner of the approximately rectangular inner frame 18.

The inner frame 18 supports a patient support frame 19, which has a seat section 21, a head section or fowler 22 which is coupled at one edge to the seat section 21 for pivotal movement about a transverse horizontal axis, a thigh section 23 which is coupled to the opposite side of the seat section 21 for pivotal movement about a transverse horizontal axis, and a foot section 24 which is coupled to the thigh section 23 for pivotal movement about a transverse horizontal axis. The head section 22 can be pivotally raised and lowered with respect to the seat section 21 by a conventional motor-driven mechanism which includes a link 26, and the thigh section 23 can be pivotally raised and lowered with respect to the seat section 21 by a further conventional motor-driven mechanism which includes a link 27, the foot section being pivotally raised and lowered with the thigh section 23.

A mattress 29 is provided on the patient support frame 19. It is possible for the mattress 29 to be a conventional foam-filled pad or the like, but in the illustrated embodiment the mattress 29 includes a inflatable air bladder which is not visible in Figure 1 but which is described later.

The bed 10 also includes a hand-held pendant 31, which is coupled to the bed through a cable 32. A patient can use the pendant 31 to manually control various devices, such as the motor-driven arrangements which move the links 26 and 27 in order to adjust the shape of the patient support frame 19. A headwall cable 33 has connectors at each end which releasably couple it to the bed 10 and to a headwall 34, the headwall 34 containing wiring which leads to conventional fixtures such as a television in the hospital room, room lights in the hospital room, reading lights in the hospital room which are directly over the bed 10, and a central nurse's station down the hall from the hospital room.

A footboard 37 is provided at one end of the outer frame 14, and two arms 41 and 42 pivotally support a left siderail 38 on the outer frame 14 for movement between a lowered position, which is shown in Figure 1, and a raised position. A right siderail 43 is movably supported in a similar manner on the outer frame 14, and is shown in the raised position. Like the pendant 31, the footboard 37 and the siderails 38 and 43 have not-illustrated manual controls which can be used to control functions such as adjustment of the shape of the patient support frame 19.

Figure 2 is a block diagram of the control circuitry within the bed 10 of Figure 1. The circuit of Figure 2 includes a bed computer 51 in the form of a circuit board mounted on the outer frame 14 of the bed 10 of Figure 1, the bed computer 51 including a conventional microprocessor 52 and a serial peripheral interface (SPI) 53. The SPI interface 53 is coupled through a serial cable 56 to an interface board 57 mounted in the right siderail 43, through a serial cable 58 to an interface board 59 mounted in the left siderail 38, through a serial cable 61 to a headwall interface board 62 mounted on the outer frame 14 near the head end of the bed, and through a serial cable 63 to an interface board 64 mounted in the footboard 37. The headwall interface board 62 is coupled by two speaker cables 66 and 67 to loudspeakers 68 and 69 mounted in the respective siderails 43 and 38.

The siderail interface board 57 in the right siderail 43 is connected by respective cables 71-75 to a mattress keyboard 76, a television (TV) keyboard 77, a nurse call keyboard 78, a lighting control keyboard 79, and an attendant keyboard 80. Each of the keyboards 76-80 is removably mounted in the siderail, and may be omitted in situations where it is not necessary. For example, the TV keyboard 77, which is used to control a television, could be omitted in a bed disposed in a hospital room that does not have a television. Similarly, the mattress keyboard 76 could be omitted in a bed which has a conventional mattress rather than the controllable inflatable mattress 29. The siderail interface board 59 in the other siderail 38 is connected in a similar manner to five equivalent keyboards.

Two cables 82 and 83 extend from the bed computer 51 to the respective siderails 43 and 38, and each contain power and ground lines FPWR and FGND for floodlights which are disposed in the siderails and illuminate the keyboards therein in a manner described in more detail later.

The footboard interface board 64 is coupled by respective cables 86 and 87 to a footboard keyboard 88 and a mattress keyboard 89.

The bed computer 51 also includes an RS-232 interface 91, which is coupled through an RS-232 cable 92 to a control unit 93 within the mattress 29, the control unit 93 being operatively coupled to an inflatable bladder 94 within the mattress. The control unit 93 includes a not-illustrated air pump and air valve which permit the air pressure within the bladder 94 to be selectively increased and decreased. The structure within the mattress 29 is not in and of itself the focus of the present invention, and is therefore not described in further detail here.

The RS-232 interface 91 is coupled through a further RS-232 cable 96 to a scale computer 97 which, like the bed computer 51 and headwall interface board 62, is supported on the outer frame 14 (Figure 1) of the bed.

The scale computer 97 includes a conventional microprocessor 98, and receives output signals from four conventional load cells 99, which are the previously-mentioned load cells supporting the inner frame 18 (Figure 1) on the outer frame 14 of the bed. The scale computer 97 includes an SPI interface 107, which is coupled through a cable 108 to a scale interface board 109 mounted in the footboard 37. The scale interface board 109 is coupled by respective cables 111 and 112 to a bed exit keyboard 113 and scale keyboard 114, which are also mounted in the footboard 37.

The bed computer 51 has outputs which selectively control operation of four motors 116-119, the motor 116 operating the drive mechanism which moves the link 26 (Figure 1) in order to pivot the head section 22 of the bed, the motor 117 operating the drive mechanism which moves the link 27 in order to pivot the knee section 23 of the bed, the motor 118 driving the head lift 16 of the bed, and the motor 119 driving the foot lift 17.

A conventional and not-illustrated braking mechanism is provided for releasably locking the casters 12 (Figure 1) against rolling movement, and a brake switch shown at 122 in Figure 2 is mechanically actuated by the braking mechanism when it is engaged, and provides an output signal to the bed computer 51 so that the bed computer 51 knows when the braking mechanism is engaged.

Figure 3 is a circuit block diagram showing in more detail the SPI interface 53 in the bed computer 51 of Figure 2. The bed computer 51 includes a microcontroller 126, which in the preferred embodiment is a conventional MC68HC705C8 made by Motorola, Inc. of Phoenix, Arizona. The microprocessor 52 is a part of the microcontroller 126.

The SPI interface 53 includes a four-to-one data multiplexer 128 and a four-to-one strobe multiplexer

129. The microcontroller 126 has an output PC2 which is connected to an inhibit input INH of the data multiplexer 128, and has two outputs PC0 and PC1 which are connected to respective select inputs of each of the multiplexers 128 and 129. The multiplexers 128 and 129 are made from conventional integrated circuits, namely a Motorola 74HC4052 in the case of multiplexer 128 and a Motorola 74HC139 in the case of multiplexer 129.

The microcontroller 126 has a serial data output MOSI which is connected to an input of the data multiplexer 128 and is coupled by the data multiplexer 128 (when not inhibited) to a respective one of four serial output lines MOSI0-MOSI3, which are each coupled through a respective conventional inverting buffer to a respective one of four connectors 131-134. The connectors 131-134 each facilitate the releasable connection to the SPI interface 53 of a respective one of the SPI cables 63, 56, 58 and 61. The connectors 131-134 each supply a respective serial input signal through a respective conventional inverting buffer to a respective one of four serial inputs MISO0-MISO3 of the data multiplexer 128, a selected one of which is coupled (when the multiplexer is not inhibited) to an output of the multiplexer 128 which is connected to a serial data input MISO of the microcontroller 126.

The microcontoller 126 also has an output PC3 which is a write strobe signal and is connected to an input of the strobe multiplexer 129, the strobe multiplexer 129 supplying this signal to a respective one of four write strobe outputs WSTB0-WSTB3 which are each coupled through a respective conventional inverting buffer to a respective one of the connectors 131-134. Similarly, an output PC4 of the microcontroller 126 serving as a read strobe is coupled to an input of the strobe multiplexer 129, the multiplexer 129 supplying this signal to a respective one of four read strobe outputs RSTB0-RSTB3 which are each coupled through a respective conventional inverting buffer to a respective one of the connectors 131-134.

The microcontroller 126 also has a shift clock output SCK which is coupled through respective conventional inverting buffers to the respective connectors 131-134. A power supply 137 supplies +8 VDC power to the connectors 131-133, and supplies +12 VDC power to the connector 134. The connectors 131-134 are each connected at 138 to a circuit ground.

In operation, the microcontroller 126 sets the output PC2 so as to enable the data multiplexer 128, and sets outputs PC0 and PC1 to select one of the connectors 131-134. Then, to serially output data, the microcontroller 126 successively serially outputs 16 bits (two bytes) on the serial output line MOSI while synchronously producing sixteen clock pulses on the shift clock output line SCK, which at the remote end of the connection will cause the 16 serial bits to be successively clocked into a 16 bit shift register that will be described in a moment. The microcontroller 126 then produces a pulse at output PC3 to serve as a write strobe indicating to the remote device that the serial transmission has been completed.

Alternatively, to read data, the microcontroller 126 produces a read strobe pulse on output PC4 in order to indicate to the selected remote device that it should load a 16 bit shift register with 16 bits (two bytes) which are to be sent to the microcontroller 126, and then issues sixteen shift clock pulses on the shift clock output line SCK to cause the remote shift register to successively send the 16 bits in the remote shift register serially to the MISO input of the microcontroller 126, where they are successively accepted.

The SPI circuitry present in the interface board 57 (Figure 2) of the right siderail 43 is shown in more detail in Figure 4. The function and timing of the data, clock and strobe signals of the SPI interface are conventional, but will be briefly explained for purposes of clarity.

More specifically, referring to Figure 4, the siderail interface board 57 has five connectors 141-145 which are each releasably connected to one end of a respective one of the cables 71-75, and the five keyboards 76-80 have respective connectors 146-150 which are each connected to the other end of a respective one of the cables 71-75. The interface board 57 also has a connector 152 which is releasably connected to the associated end of serial cable 56. The +8 VDC power signal from the cable 56 and connector 152 is supplied to a voltage regulator 153, which outputs regulated +5 VDC power to the interface board 57 and, through the cables 71-75, to each of the keyboards 76-80.

The interface board 57 has two 16-bit shift registers 156 and 157. The shift registers 156 and 157 are made from conventional parts, the shift register 156 being made from two Motorola 74HC597 8-bit shift registers, and the shift register 157 being made from two Motorola 74HC595 8-bit shift registers. The shift register 157 includes a 16-bit output latch 158.

The shift register 156 receives the read strobe signal RSTB1 and the shift clock signal SCK1 from the cable 56 through connector 152 and respective conventional inverting buffers, and supplies the serial output signal MISO1 through a conventional inverting buffer and the connector 152 to the cable 56. The shift register 157 receives the shift clock signal SCK1, the serial data signal MOSI1, and the write strobe signal WSTB1 from the cable 56 through the connector 152 and respective conventional inverting buffers.

When the microcontroller 126 of Figure 3 is serially outputting data to the right siderail, the shift clock signal SCK1 successively shifts into the 16-bit shift register 157 the 16 serial bits sent across the line MOSI1, and then in response to the subsequent write strobe signal WSTB1, the shift register 157 simultaneously transfers all 16 bits to the latch 158, which then holds the bits and uses each to control a respective one of 16 output lines shown along the right side of the shift register 157 in Figure 4, as described later. When the microcontroller 126 of Figure 3 reads data from the interface board 57 of Figure 4, the read strobe signal RSTB1 is issued to cause the shift register 156 to load itself with 16 bits each representative of the logic level present at a respective one of 16 inputs shown along the right side thereof in Figure 4, and then in response to the 16 successive pulses on the shift clock line SCK1, the shift register 156 successively serially outputs the 16 bits on line MISO1.

The mattress keyboard 76 has two momentary push-button switches 161 and 162 which each have one end connected to +5 VDC power and the other end connected through the cable 71 to the midpoint of a respective two-resistor voltage divider provided between circuit ground and a respective data input of the shift register 156. Through the bed computer 51 (Figure 2), the switches 161 and 162 respectively cause the control unit 93 of the mattress 29 to increase and decrease the inflation pressure in the bladder 94 of the mattress. The mattress keyboard 76 also includes a light emitting diode (LED) 163 having its anode connected to +5 VDC power and its cathode connected through the cable 71 to a respective output of the latch 158 associated with shift register 157. The LED 163 is selectively illuminated by the bed computer 51 to indicate whether or not the inflation pressure of the mattress 29 is being controlled by the patient in a manual mode or by the bed computer 51 in an automatic mode.

The TV keyboard 77 includes three momentary push-button switches 166-168 which each have one end connected to +5 VDC power and the other end connected through the cable 72 and a respective two-resistor voltage divider to respective inputs of the shift register 156. The switch 166 can be repeatedly pressed to successively turn on a television in the hospital room, then cycle through the channels, and then turn off the television. The switches 167 and 168 are used to respectively increase and decrease the volume of an audio signal (typically from the television) which is supplied to the speakers 68 and 69 in the siderails in a manner described in more detail later.

The nurse call keyboard 78 has a momentary push-button switch 171 with one end connected to +5 VDC power and the other end connected through the cable 73 and a two-resistor voltage divider to a respective input of shift register 156, and has two LEDs 172 and 173 with anodes connected to +5 VDC power and cathodes connected through the cable 73 and respective resistors to respective outputs of the latch 158 for shift register 157. The switch 171 causes the bed computer 51 to send a nurse call signal to a remote nurse's station through the headwall cable 33 (Figure 2), the bed computer using the LED 172 to confirm to the patient that the nurse call signal has been sent to the nurse's station, and using the LED 173 to indicate to the patient that a nurse is answering the call.

The lighting control keyboard 79 has two momentary push-button switches 176 and 177 which each have one end connected to +5 VDC power and the other end connected through a respective two-resistor voltage divider to a respective input of shift register 156. The switch 176 is used to turn on and turn off the room lights in the hospital room, and the switch 177 is used to turn on and turn off the reading lights provided in the hospital room above the bed 10.

The attendant keyboard 80 has seven momentary push-button switches 181-187 which each have one end connected to +5 VDC power and the other end connected through the cable 75 and a respective two-resistor voltage divider to a respective input of the shift register 156. The switches 181 and 182, while pressed, respectively cause the bed computer 51 to energize the motor 116 (Figure 2) for rotation in respective opposite directions to respectively raise or lower the head section 22 (Figure 1) of the patient support. Similarly, the switches 183 and 184, while pressed, respectively cause the bed computer 51 to energize the motor 117 for rotation in respective opposite directions to respectively raise and lower the knee section 23 of the patient support. Likewise, the switches 185 and 186, while pressed, cause the bed computer 51 to simultaneously energize both of the motors 118 and 119 for rotation so as to simultaneously respectively raise or lower each of the lifts 16 and 17, to thereby raise or lower the entire litter section 13. The nurse call switch 187 is connected in parallel with the nurse call switch 171, and thus has the same functional effect.

Provided directly on the interface board 57 are four momentary push-button switches 191-194, which each have one end connected +5 VDC power and the other end connected to the same two-resistor voltage dividers as the respective switches 181-184 of the attendant keyboard 80. Since the switches 191-194 are connected in parallel with the switches 181-184, their respective functional effects are the same.

The switches and LEDs on the keyboards 76-79 and on the interface board 57 are all physically located on the inner side of the siderail 43, or in other words the side which faces the patient. Thus, the switches are all readily accessible to and can be operated by the patient. The switches on the attendant keyboard 80 are provided on the outer side of the siderail 43, or in other words the side which faces away from the patient, and are not easily accessible to the patient but instead are provided for operation by a nurse or other patient attendant.

Each switch and LED serves as an interface element which is part of an operator interface usable by a patient and/or an attendant. The specific function of the LEDs, of course, is to serve as status indicators.

The interface board 57 has a further connector 201 releasably coupled to the cable 82 carrying the floodlight power and ground signals FPWR and FGND. The signals FPWR and FGND are connected across a floodlight LED 202 provided on the interface board adjacent a prism 203. The prism 203 directs the light from the LED 202 onto the switches 191-194 so that they can be easily seen by the patient in a dimly-lit room. The signals FPWR and FGND are also each supplied through each of the cables 71-75 to the respective keyboards 76-80, which each have mounted thereon a respective floodlight LED 206-210 disposed adjacent a respective prism 211-215.

The headwall interface board 62 and hand-held pendant 32 of Figure 2 are shown in more detail in Figure 5. The headwall interface board 62 has a connector 221 releasably coupled to the associated end of serial cable 61, and has two 16-bit shift registers 222 and 223 which are equivalent to the shift registers 156 and 158 discussed above in association with Figure 4. The manner in which the shift registers 222 and 223 are coupled to the signals of cable 61 is similar to that already described above in association with Figure 4, and is therefore not described again in detail here.

The headwall interface board 62 has a voltage regulator 226, which is similar to the voltage regulator 153 of Figure 4 and outputs regulated +5 VDC power. The headwall interface board 62 also has a connector 227 which releasably couples one end of the pendant cable 31 to the headwall interface board 62, the other end of the cable 31 being coupled by a connector 228 to the pendant 32. The connector 228 is preferably a non-releasable connector, or alternatively is internal to the pendant 32, so that a patient cannot inadvertently disconnect the pendant 32 from the cable 31.

The headwall interface board 62 has a further connector 231 which releasably couples one end of the headwall cable 33 to the headwall interface board 62, the connector 231 being coupled at 232 to a socket/header section 233 which is described in more detail later. For now, it is sufficient to point out that the socket/header section 233 does not alter the electrical characteristics of signals passing between the connector 231 and the circuitry on the interface board 62. The headwall cable 33 carries a set of signals which are themselves conventional, and which are described in more detail later. The headwall interface board 62 also has two speaker connectors 236 and 237, which are each releasably coupled to an associated end of one of the speaker cables 66 and 67.

The pendant 32 has eight momentary push-button switches, each of which has one end connected to +5 VDC power and the other connected through the cable 31 and a respective two-resistor voltage divider to a respective input of the shift register 222. The pendant 32 also has two LEDs 248 and 249 which each have an anode connected to +5 VDC power and a cathode connected through the cable 31 and a respective resistor to a respective output of the latch in shift register 223. The switches 239-246 are respectively functionally equivalent to the switches 181-184, 166-168 and 171 in Figure 4, and the LEDs 248 and 249 are respectively equivalent to the LEDs 172 and 173 in Figure 4.

The headwall interface board 62 has two conventional opto-coupler circuits 252 and 253. The headwall cable 33 supplies through the connector 231 and socket/header section 233 a pair of signals N. CALL LT+ and N. CALL LT- which are connected to respective inputs of the opto-coupler 252, the output of the opto-coupler 252 being connected through a respective two-resistor voltage divider to a respective input of the shift register 222. Similarly, related signals N. ANS. LT+ and N. ANS. LT- from the head wall cable 33 are applied through socket/header section 233 to respective inputs of the opto-coupler circuit 253, the output of the circuit 253 being connected through a respective voltage divider to a respective input of shift register 222. The outputs of the opto-coupler circuits 252 and 253, through the bed computer 51, control the NURSE CALL and NURSE ANSWER LEDs 172 and 173 in Figure 4, as well as the NURSE CALL and NURSE ANSWER LEDs 248 and 249 in the pendant 32 of Figure 5.

The headwall interface board 62 includes nine relays 256-264, each of which has a coil with one end connected to +12 VDC power from the connector 221 and the other end connected through a respective relay driver circuit to a respective output of the latch portion of shift register 223. Each of the relay driver circuits includes a resistor 266 connected between the latch output and ground, a resistor 267 connected between the latch output and the base of a transistor 268, and a diode having its anode and cathode respectively coupled to the emitter and collector of the transistor 268, the emitter of the transistor being also connected to ground and the collector of the transistor being also connected to the coil of the associated relay.

The relay 256 is controlled by the bed computer 51 in response to operation of the TV ON/CH/OFF switch 166 (Figure 4) or 243 (Figure 5), and has a contact connected to a signal TV+ of the socket/header section 233 and a normally open terminal coupled to a signal TV- of the section 233.

The scale computer 97 can be selectively enabled to carry out a function in which it monitors the signals from the load cells 99 so as to detect a situation in which the patient is attempting to exit (or has in fact exited) the bed 10. Techniques for detecting patient exit are known and, since they are not in and of themselves the focus of the present invention, they are not described in detail here. Upon detecting patient exit, the scale computer 97 notifies the bed computer 51, which can actuate the relay 257 of Figure 5 in order to notify the central nurse's station through the headwall connector 33 that a patient exit is in progress. The relay 256 has a contact connected to a PRIORITY COM signal at the socket/header section 233, and has normally closed and normally open terminals respectively connected to PRIORITY-NC and PRIORITY-NO signals at the section 233.

The relay 258 is actuated by the bed computer 51 when it detects actuation of one of the NURSE CALL switches 171 (Figure 4), 187 (Figure 4) or 246 (Figure

5). The relay 256 has a contact connected to signals N. CALL INTERLOCK and N. CALL+ at the section 233, and has normally closed and normally open terminals respectively connected to signals N. CALL-NC and N. CALL-NO at the section 233.

The relay 259 is actuated and deactuated by the bed computer 51 in response to successive presses of the room light control switch 176 in Figure 4, and has a contact connected to a ROOM LT signal and a normally open terminal connected to a LT COM signal at the section 233. Similarly, a relay 260 is actuated and deactuated by respective presses of the reading light control switch 177 in Figure 4, and has a contact connected to a READ LT signal and a normally closed terminal connected to the LT COM signal at the section 233.

The relays 261-264 are respectively controlled by four outputs of the latch of shift register 223, which together represent a 4-bit binary number. As the VOLUME UP switch 167 in Figure 4 is successively pressed, the binary number is progressively incremented until it reaches a maximum value (1111), and as the VOLUME DOWN switch 168 in Figure 4 is successively pressed, the number is progressively decremented until it reaches a minimum value (0000).

Four resistors 271-274 are connected in series between lines POT HI COM and POT LO COM at the socket/header section 233. Four additional resistors 276-279 each connect the upper end in Figure 5 of a respective one of the resistors 271-274 to the contact of a respective one of the relays 261-264. The normally closed terminal of each of the four relays 261-264 is connected to POT LO COM line of section 233, and the normally open terminals of the relays 261-264 are all connected to a POT WIPER line of the section 233. The relays 261-264 and the resistor network or divider including resistors 271-274 and 276-279 together function to emulate a potentiometer having its end terminals respectively connected to the POT HI COM and POT LO COM lines of the section 233 and its wiper connected to the POT WIPER line of section 233, the resistance between the wiper and either of the end terminals varying as a function of the value of the 4-bit binary number controlling the relays 261-264.

The headwall cable 33 provides through the socket/header section 233 an AUDIO SHIELD line which is connected to each of the speaker connectors 236 and 237, a SPEAKER LO COM line which is also connected to each of the speaker connectors 236 and 237, and two audio signals on lines SPEAKER HI RT and SPEAKER HI LFT which are each connected to a respective one of the speaker connectors 236 and 237.

The headwall interface board 62 has an INTERLOCK jumper between two lines of the section 233, an AUDIO TRANSFER jumper between two lines of the section 233, and a diode 281 connected between two lines DC+ and AUX POS SUPPLY of the section 233. These are provided in a conventional manner for conventional purposes which are not pertinent to the present invention, and there are therefore shown here for purposes of completeness but are not described in detail.

Figure 6 shows the socket/header section 233 of Figure 5 in greater detail. In particular, two conventional 40-pin sockets are installed in the headwall interface board 62, each having 20 terminals 288 along one side which are each connected at 232 to a respective terminal of the connector 231, and 20 terminals 289 along the other side which are each connected to the circuitry of the interface board 62 in the manner described above (or are spare pins which are not used). As is known by those of ordinary skill in the art, the terminals 288 and 289 of the sockets 286 and 287 each have a blind opening therein which can receive a respective pin of a 40-pin integrated circuit or a respective pin of a 40-pin platform or header.

As shown in Figure 6, the preferred embodiment includes two 40-pin headers 291 and 292, which are respectively removably plugged into the sockets 286 and 287. In particular, each has 20 pins 293 along one side which each engage the opening in a respective one of the terminals 288 in the associated socket, and 20 pins 294 along the other side which each engage the opening in a respective one of the terminals 289 of the associated socket. Each header has several jumpers 296, which extend between a respective pair of pins 293 and 294 located directly across from each other. Thus, the socket/header section does not electrically alter any of the signals passing through it, but merely determines the pattern in which the wires of the cable 33 are coupled to respective signal lines on the interface board.

As mentioned above the set of signals in the cable 33 is relatively standard. However, the assignment of the signals to the various lines of the cable 33 may be different in different hospitals. If a hospital has headwall cables which each have the standard headwall signals on different lines than is illustrated in Figure 6, it is sufficient to replace the headers 291 and 292 with substitute headers which are similar, except that the arrangement of jumpers on the substitute headers is different so as to properly electrically connect each of the signals from the interface board to the appropriate associated line within the cable 33 for that hospital.

An audio signal from the headwall 34 which is intended for the loudspeakers 68 and 69 is supplied through the cable 33 to the lines POT HI COM and POT LOW COM on the interface board 62. As shown in Figure 6, the cable 33 includes a jumper 301 which connects the POT LOW COM line to the SPEAKER LO COM line on the interface board 62, and jumpers 302 and 303 which each connect the POT WIPER line from the board 62 to a respective one of the lines SPEAKER HI RT and SPEAKER HI LFT on the board 62. In other words, the audio signal is applied to the end terminals of the potentiometer simulated by relays 261-264 and resistors 271-274 and 276-279, and each of the speakers 68 and 69 is connected between the wiper and one end terminal of the simulated potentiometer.

Figure 7 is a circuit diagram showing in greater detail the RS-232 interface 91 of the bed computer 51 of Figure 2. In particular, a serial output line 306 from the microprocessor 52 (Figure 2) is connected to inputs of two opto-coupler circuits 307 and 308, the opto-coupler circuits 307 and 308 each having an output which is supplied through a respective conventional inverting buffer to a respective connector 311 or 312. The connectors 311 and 312 each releasably couple the RS-232 interface of the bed computer 51 to an end of a respective one of the RS-232 cables 97 and 92.

Further opto-coupler circuits 313 and 314 each receive from a respective one of the cables 97 and 92 through a respective conventional inverting buffer a serial input signal, the opto-coupler circuits 313 and 314 each producing an output which is supplied to a respective input of an OR gate 317, the output of the OR gate being a serial input line 318 to the microprocessor 52. Those of ordinary skill in the art are thoroughly familiar with the conventional protocol for RS-232 serial communication, and it is therefore not described in detail here.

Referring to Figure 2, the interface board 64 and keyboards 88 and 89 of the footboard 37 are not shown in detail, but correspond generally to the interface board and keyboards shown in Figure 4 for the siderail 43. The same is true for the scale interface board 109 and keyboards 113 and 114 of the footboard 37. The specific push-buttons switches and LEDs of the keyboards 88-89 and 113-114 are not identical to those for the siderails, but for purposes of the present invention it will be recognized that the underlying concept and functions are similar, and a detailed discussion of the circuitry within the foot board 37 has therefore been omitted for simplicity.

Figure 8 is a fragmentary diagrammatic sectional view of the left siderail 38, taken along the section line 8-8 in Figure 1. The siderail includes a plastic frame or housing 331 having a transverse opening 332 therethrough, and has spaced cover plates 333 and 334 which are removably secured in opposite ends of the opening 332. The electronics of the siderail 38, which were described above in association with Figure 2, are provided between the cover plates 333 and 334.

In particular, the loudspeaker 69 is mounted on the portion of the cover plate 333 which has a plurality of openings through it, and the remainder of the cover plate 333 has an approximately sawtooth shape when viewed in section, including several portions 336 which are inclined to face approximately toward the head of the patient and several shorter portions 337 which are inclined to face approximately toward the feet of the patient. Each of the portions 336 has several rearwardly projecting posts 338, and the circuit boards 59 and 76-79 are each secured to the posts of a respective portion 336 by screws 339. The portions 336 each have an opening therethrough, and a sheet 341 of flexible plastic material is secured to the portion 336 so as to extend across the entirety of the opening therethrough. The circuit board 80 is mounted on the opposite cover plate 334 in a similar manner. For purposes of clarity, the cables which electrically interconnect the circuit boards have been omitted in Figure 8.

Each of the portions 337 of the cover plate 333 has at least one opening therethrough, in which is secured one end of a respective one of the prisms 203 and 211-214, as shown for prism 211 in Figure 8, so that an outer surface of the prism is flush with the outer surface of the plate portion 337. The opposite end of each prism has an opening 334, which is larger than and removably receives the associated LED on the corresponding circuit board, as shown in Figure 8 for the LED 206 on circuit board 76.

Figure 8 also shows how the push-button switch 161 mounted on the circuit board 76 is closely adjacent the rear side of the plastic sheet 341, so that the patient can operate the switch 166 by pressing on the outer side of the flexible sheet 341. Also, Figure 8 shows how the LED 163 on circuit board 76 is located immediately behind a portion of the flexible sheet 341 so that, when the LED is illuminated, it is visible through the sheet 341. Each plastic sheet 341 has not-illustrated indicia over each switch identifying the function of the switch, and has not-illustrated indicia over or adjacent each LED in order to identify the status condition represented by the LED. It should thus be evident from Figure 8 how light from the LED 206 is directed by the prism 211 onto the adjacent plastic sheet 341, so that the indicia thereon are clearly illuminated for a patient in a dark or dimly lit room.

OPERATION

Referring to Figure 2, the bed computer 51 uses the SPI interface 53 to continuously cyclically interrogate the interface boards 57, 59, 62 and 64 in the siderails, headwall interface and footboard, for example to determine if any of the momentary push-button switches in any of the keyboards or in the pendant has been pressed. The bed computer 51 also uses the SPI interface to keep the various LEDs updated. Likewise, the scale computer 97 uses the SPI interface 107 to obtain information from the scale interface board 109 regarding the state of momentary push-button switches on the keyboards 113 and 114, and to update any LEDs which may be present on keyboards 113 and 114.

The bed computer 51 uses the RS-232 interface 91 to send a message containing one or more bytes to both the mattress 29 and scale computer 97, each message containing an address portion which indicates whether the message is intended for the mattress 29 or the scale computer 97. When the mattress 29 receives such a message containing its address, it takes the action specified in the message and/or sends a return message to the bed computer 51. Likewise, when the scale computer 97 receives such a message containing its address, it takes the specified action and/or sends a return message to the bed computer 51. The mattress 29 and scale computer 97 do not initiate transmissions to the bed computer 51, but instead send messages only in response to a message from the bed computer 51, so that the mattress 29 and scale computer 97 do not attempt to simultaneously send messages through the OR gate 317, the result of which would be a conflict producing errors. The bed computer 51 thus serves as a master with respect to the RS-232 interface, and the mattress 29 and scale computer 97 serve as slaves. The bed computer 51 sends frequent messages to the mattress 29 and the scale computer 97, so that each is assured of being able to send urgent messages to the bed computer 51 with minimal delay despite the fact that they are slaves rather than masters with respect to the RS-232 interface.

If manual operation of the mattress 29 has been enabled (for example by using mattress keyboard 89 in the footboard 37), the bed computer 51 uses SPI interface 53 to illuminate LED 163 in Figure 4. In manual mode, in response to manual operation of the MATTRESS FIRM switch 161 or MATTRESS SOFT switch 162, the bed computer 51 detects the switch actuation through the SPI interface 53 and then uses the RS-232 interface 91 to cause the control unit 93 of mattress 29 to either increase or decrease air pressure within bladder 94. The switches 161 and 162 are ignored if manual mode is disabled.

Each time the TV ON/CH/OFF switch 166 in Figure 4 is manually actuated, the bed computer 51 detects the actuation through SPI interface 53 and then uses the SPI interface to cause the headwall interface board 62 to turn the relay 256 on and then back off, so that a pulse is sent across lines TV+ AND TV- through the headwall cable 33 to the headwall 34, the headwall 34 responding in a conventional manner to the successive pulses by turning on a television, cycling through the channels, and then turning the television off. When one of the volume up or down switches 167 or 168 in Figure 4 is pressed, the bed computer 51 detects it through the SPI interface 53 and then uses the interface 53 to increase or decrease the 4-bit binary number supplied to the relays 261-264 on headwall interface board 62 in order to change the volume of the signal being supplied to the speakers 68 and 69 in the siderails. The switches 243-

245 in the pendant 32 (Figure 5) control the television and audio volume in a similar manner.

If one of the NURSE CALL switches 171 (Figure 4), 187 (Figure 4) or 246 (Figure 5) is actuated, the bed computer 51 detects it through SPI interface 53 and then uses the interface 53 to actuate relay 258 in order to send a nurse call signal through the headwall interface cable 33 to the central nurse's station. The nurse's station responds with signals through the headwall cable 33 that actuate the opto-coupler 252 (Figure 5), which is detected by the bed computer 51 through the SPI interface 53 and causes the bed computer to use the interface 53 to actuate the NURSE CALL LEDs 172 (Figure 4) and 248 (Figure 5). When a nurse subsequently presses a button at the central station to indicate that the request is being answered, the central station sends a further signal through the headwall cable 33 to actuate the opto-coupler 253 (Figure 5), which produces a signal that causes the bed computer 51 to actuate the NURSE ANSWER LEDs 173 (Figure 4) and 249 (Figure 5).

Each time the patient actuates the ROOM LIGHT switch 176 or READING LIGHT switch 177 in Figure 4, the bed computer 51 detects the actuation through the SPI interface 53 and then uses the interface 53 to change the state of a respective one of the relays 259 and 260 (Figure 5) on the headwall interface board 62 in order to send through the headwall cable 33 a signal which changes the state of (turns on or turns off) the room lights or the reading lights.

Actuation of any one of the bed motion switches 181-186 of Figure 4, 191-194 of Figure 4 or 239-242 of Figure 5 is detected by the bed computer 51 through the SPI interface 53, and results in energization of one or more of the motors 116-119. In particular, if one of the HEAD UP switches 181, 191 or 239 is pressed, the motor 116 is actuated in a direction which causes the head section 22 (Figure 2) of the patient support section to be raised, whereas actuation of any one of the HEAD DOWN switches 182, 192 or 240 causes the bed computer 51 to actuate the motor 116 in the opposite direction to lower the head section 22.

Similarly, actuation of one of the KNEE UP switches 183, 193 or 241 causes the bed computer 51 to actuate motor 117 in a direction raising the knee section 23, whereas actuation of one of the KNEE DOWN switches 184, 194 or 242 causes the bed computer 51 to actuate motor 117 in a direction which lowers the knee section 23. Actuation of the BED UP switch 185 causes the bed computer 51 to actuate both of the motors 118 and 119 in a direction raising the entire litter section 13 of the bed, whereas actuation of the BED DOWN switch 186 causes the bed computer 51 to actuate both of the motors 118 and 119 in a direction lowering the entire litter section 13.

If the scale computer 97 (Figure 2) determines from monitoring the load cells 99 that a patient is attempting to exit the bed, then after receiving the next RS-232 message from bed computer 51, the scale computer 97 sends a reply causing the bed computer 51 to use SPI interface 53 to actuate relay 257 on headwall interface board 62, in order to send a PRIORITY signal through headwall cable 33 to notify the remote nurse's station that a patient exit situation has been detected.

Referring to Figure 6, if the bed 10 is shipped to a hospital using the headwall cable configuration shown for the preferred embodiment at 33, the platforms 291 and 292 are installed in the sockets 286 and 287 in order to connect the signals in cable 33 to the respective corresponding signals on the headwall interface board 62 in the pattern determined by the jumpers 296. On the other hand, if the bed 10 is being shipped to a hospital in which the assignment of standard signals to the wires of the headwall cable is different, the platforms 291 and 292 shown in Figure 6 are replaced with similar platforms having a different pattern or configuration of jumpers in order to realize the same functional result, namely that each of the signals in the headwall cable is connected through the jumpers to its correct counterpart on the headwall interface board 62.

Although a preferred embodiment of the invention has been illustrated and described in detail for illustrative purposes, it will be recognized that there are variations of this embodiment, including the rearrangement of parts, which lie within the scope of the present invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An apparatus, comprising: a bed having a control circuit, an operator interface portion which is at a location on said bed spaced from said control circuit and which includes an operator interface element, and means defining a serial communication link between said operator interface portion and said control circuit.

2. An apparatus according to Claim 1, wherein said bed has a frame portion and has a patient retaining part movably supported on said frame portion, said control circuit being provided on said frame portion and said operator interface portion being provided on said retaining part.

3. An apparatus according to Claim 1, wherein said bed includes a frame portion having at one end thereof a footboard, said control circuit being provided on said frame portion and said operator interface portion being provided in said footboard.

4. An apparatus according to Claim 1, wherein said operator interface portion includes a hand-held pendant having thereon said operator interface element.

5. An apparatus according to Claim 1, wherein said operator interface element is a manually operable switch, and wherein said bed has a controllable element, said control circuit having means for detecting a state of said switch through said serial communication link

and for effecting control of said controllable element as a function of the state of said switch.

6. An apparatus according to Claim 1, wherein said operator interface element is a visually perceptible status indicator, said control circuit controlling said status indicator through said serial communication link to display a status condition.

7. An apparatus according to Claim 1, wherein said control circuit includes a first serial communication circuit and said operator interface portion includes a first circuit board having thereon a second serial communication circuit coupled by said serial communication link to said first serial communication circuit, said operator interface portion further including a second circuit board removably mounted on said bed and having thereon said operator interface element, and means for electrically coupling said operator interface element on said second circuit board to said second communication circuit on said first circuit board.

8. An apparatus according to Claim 7, wherein said means coupling said operator interface element to said second serial communication circuit includes said first circuit board having thereon a connector coupled to said second serial communication circuit, and includes a cable electrically coupling said operator interface element to said connector.

9. An apparatus according to Claim 7, wherein said operator interface portion includes a third circuit board which is removably mounted on said bed and has thereon a further operator interface element, and means

electrically coupling said further operator interface element to said second serial communication circuit on said first circuit board.

10. An apparatus according to Claim 7, wherein said second serial communication circuit includes a first shift register having a plurality of inputs and a second shift register having a plurality of outputs, said second circuit board having thereon a further operator interface element, one of said operator interface elements being a manually operable input element which is electrically coupled to a respective one of said inputs of said first shift register, and the other of said operator interface elements being a visually perceptible status indicator which is electrically coupled to a respective one of said outputs of said second shift register.

11. An apparatus according Claim 7, wherein said operator interface element has a first terminal electrically coupled to a predetermined DC voltage on said first circuit board, and has a second terminal electrically coupled to said second serial communication circuit.

12. An apparatus according Claim 1, wherein said operator interface portion includes a circuit board having thereon said operator interface element and a light-emitting element, and includes a light-directing optical element which is adjacent said light-emitting element and illuminates said operator interface element with light emitted by said light-emitting element.

13. An apparatus according to Claim 1, wherein said serial communication link is a digital serial communication link.

14. An apparatus, comprising: a bed having a control circuit, an operator interface portion which is at a location spaced from said control circuit and which includes a first circuit board and a second circuit board, said first circuit board having thereon an interface circuit and said second circuit board being removably mounted on said bed and having thereon an operator interface element which is detachably electrically coupled to said interface circuit on said first circuit board, and means defining a communication link between said control circuit and interface circuit.

15. An apparatus according to Claim 14, wherein said first circuit board has thereon a further operator interface element which is electrically coupled to said interface circuit.

16. An apparatus according to Claim 14, wherein said operator interface portion includes a third circuit board removably mounted on said bed and having thereon a further operator interface element which is detachably electrically coupled to said interface circuit.

17. An apparatus according to Claim 14, wherein said operator interface element has a first terminal electrically coupled to a predetermined voltage on said first circuit board, and has a second terminal electrically coupled to said interface circuit.

18. An apparatus according to Claim 14, wherein said bed has a controllable element, and wherein said

operator interface element is a manually operable switch, said control circuit having means for detecting the state of said switch through said communication link and for effecting control of said controllable element as a function of the detected state of said switch.

19. An apparatus according to Claim 14, wherein said operator interface element is a visually perceptible status indicator, and wherein said control circuit controls said status indicator through said communication link to effect a display of a status condition.

20. An apparatus according to Claim 14, wherein said bed includes a frame portion and a patient retaining part movably supported on said frame portion, said control circuit being provided on said frame portion and said operator interface portion being provided on said retaining part.

21. An apparatus according to Claim 14, wherein said bed includes a frame portion having at one end thereof a footboard, said control circuit being supported on said frame portion and said operator interface portion being provided on said footboard.

22. An apparatus according to Claim 14, including a controllable sub-system removably supported on said bed, and means defining a serial communication link detachably operatively coupling said controllable sub-system and said control circuit for facilitating control of said sub-system by said control circuit.

23. An apparatus, comprising: a bed having a control circuit with a plurality of first terminals, a

headwall connector with a plurality of second terminals, and removable jumper means for electrically coupling said first terminals to respective said second terminals according to a predetermined pattern.

24. An apparatus according to Claim 23, including a socket having a plurality of first pins each electrically coupled to a respective one of said first terminals and having a plurality of second pins each electrically coupled to a respective one of said second terminals, and a configuration part removably engaged with said socket, said configuration part having a plurality of first pins which each engage a respective one of said first pins of said socket, having a plurality of second pins which each engage a respective one of said second pins of said socket, and having means for electrically coupling said first pins thereof to respective said second pins thereof.

25. An apparatus according to Claim 24, including a further configuration part which is interchangeable with said first-mentioned configuration part, said further configuration part having a plurality of first pins which each engage a respective one of said first pins of said socket, having a plurality of second pins which each engage a respective one of said second pins of said socket, and having means for electrically coupling said first pins thereof to respective said second pins thereof according to a second predetermined pattern which is different from said first-mentioned predetermined pattern.

26. An apparatus, comprising: a bed having a control circuit with a digital volume control output, an audio sound generating element, and means responsive to

an audio signal and to said digital volume control output for supplying said audio signal to said sound generating element with an amplitude which varies as a function of said digital volume control output.

27. An apparatus according to Claim 26, including manually operable volume level input means coupled to said control circuit, said control circuit varying said digital volume control output in response to manual operation of said volume level input means.

28. An apparatus according to Claim 27, wherein said volume level input means includes manually actuable first and second switches electrically coupled to said control circuit, manual actuation of said first and second switches respectively causing an increase and a decrease in the amplitude of the signal supplied to said sound generating element.

29. An apparatus according to Claim 26, wherein said means for supplying said audio signal to said sound generating element includes a network having a plurality of interconnected resistors and switches, said digital volume control output including a plurality of logic signals which each control a respective one of said switches.

30. An apparatus according to Claim 29, wherein said network includes a plurality of first resistors connected in series between first and second terminals across which said audio signal is applied, a plurality of second resistors each having a first end coupled to an end of a respective said first resistor and a second end coupled to a respective said switch, each said switch being coupled to a third terminal and

respectively coupling the second end of the associated second resistor to a respective one of said third terminal and a predetermined voltage when said switch is respectively in first and second states, said sound generating element being connected between said third terminal and one of said first and second terminals.

31. An apparatus according to Claim 30, wherein said network includes a plurality of relays which each have a coil to which is applied a respective said logic signal, a common contact connected to the second end of the associated second resistor, a normally open terminal connected to said third terminal, and a normally closed terminal connected to said predetermined voltage.

32. An apparatus, comprising: a bed having a control circuit, an operator interface element electrically coupled to said control circuit, a light-emitting element, and a light-directing optical element which is adjacent said light-emitting element and which illuminates said operator interface element with light emitted by said light-emitting element.

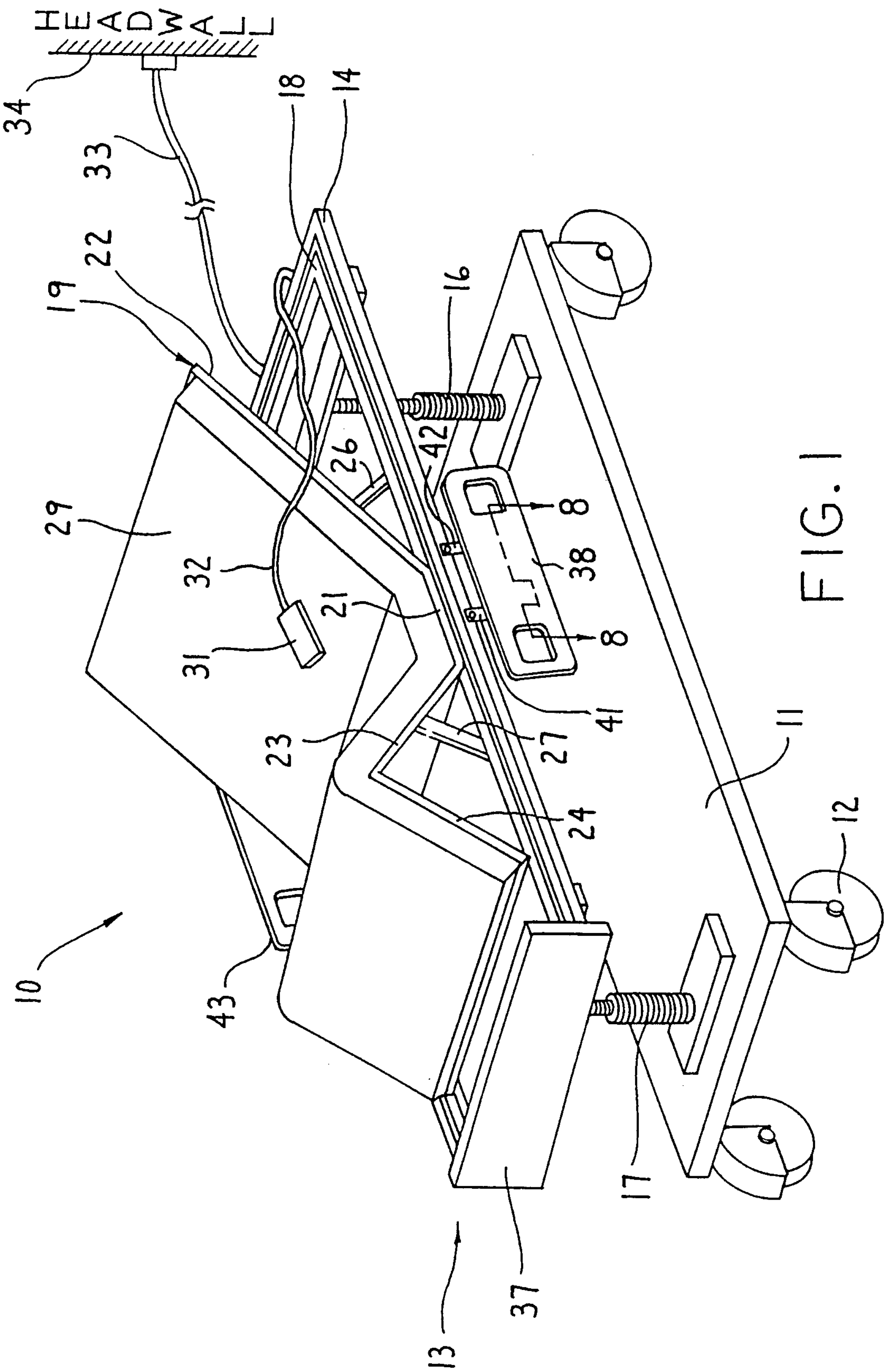
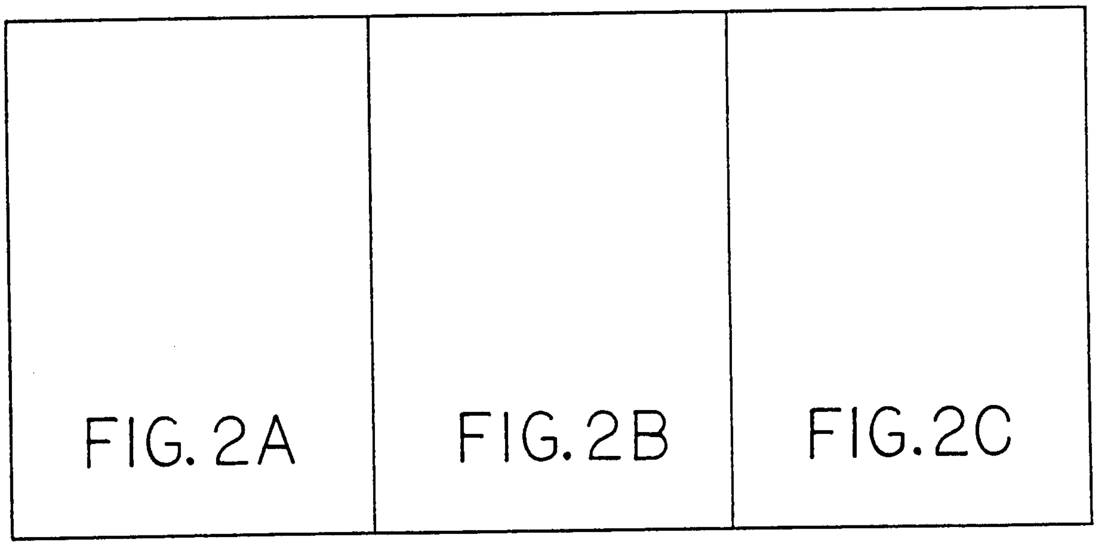

HEADWALL
34
33
14
18
22
19
16
29
26
42
32
21
31
38
8
8
41
23
27
24
11
12
10
43
17
37
13

FIG. 1

FIG. 2



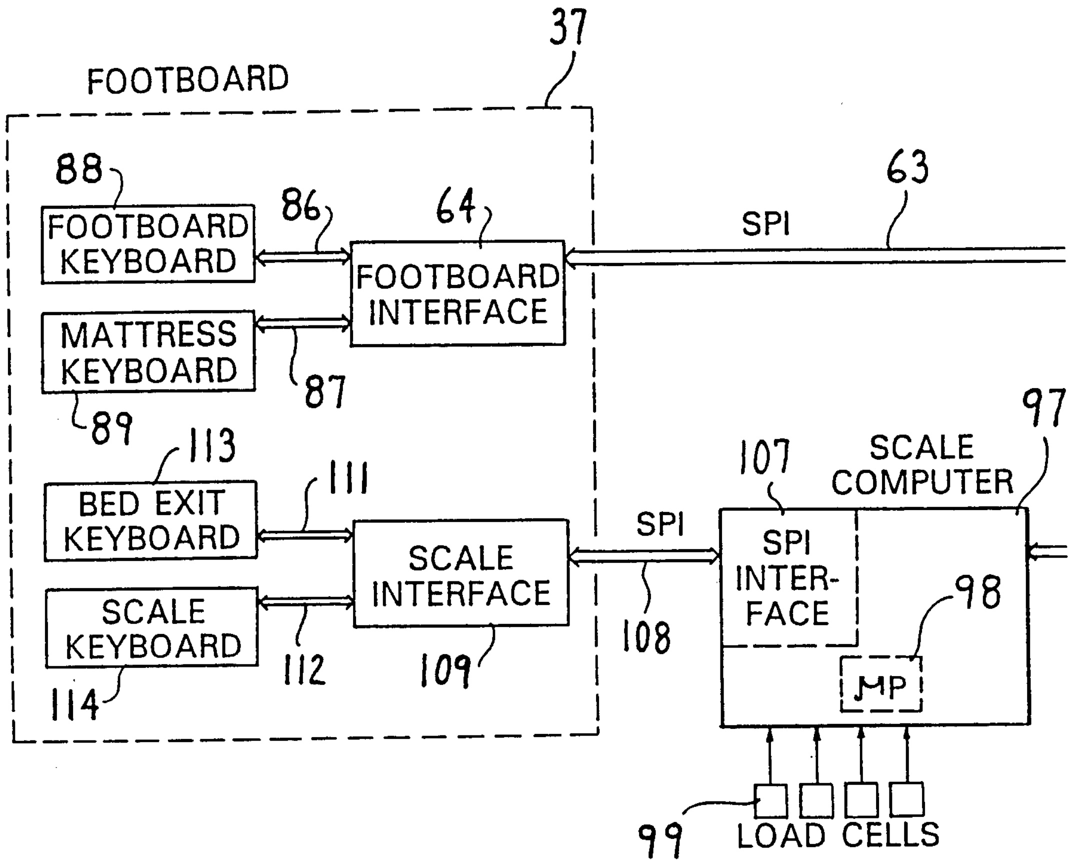

37
FOOTBOARD
88
FOOTBOARD KEYBOARD
86
64
FOOTBOARD INTERFACE
SPI
63
MATTRESS KEYBOARD
87
89
113
BED EXIT KEYBOARD
111
SCALE INTERFACE
SPI
SCALE KEYBOARD
112
109
114
108
107
SCALE COMPUTER
97
SPI INTER-FACE
98
MP
99
LOAD CELLS

FIG.2A

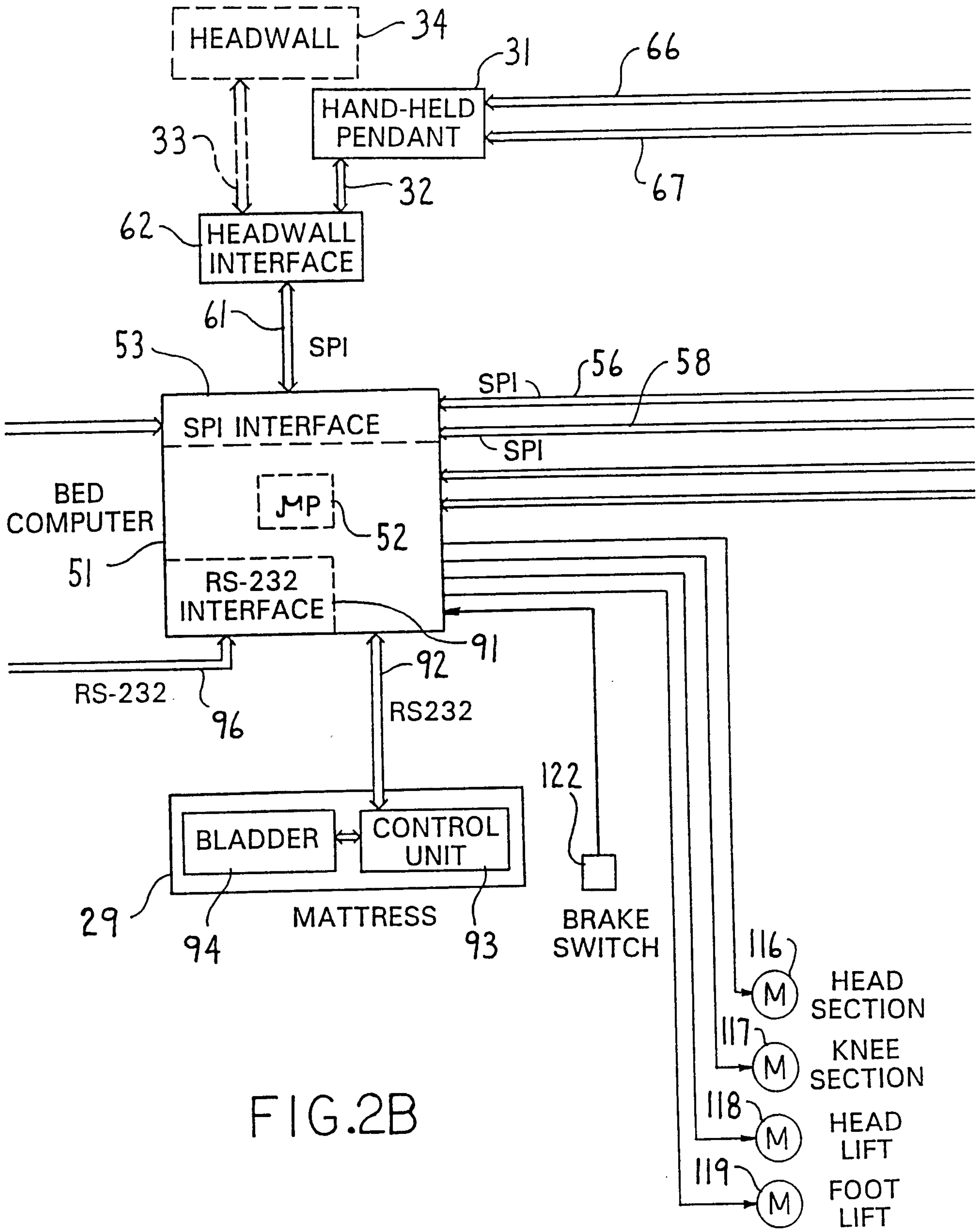

HEADWALL
34
31
66
HAND-HELD PENDANT
33
32
67
62
HEADWALL INTERFACE
61
SPI
53
SPI
56
58
SPI INTERFACE
SPI
BED COMPUTER
μP
52
51
RS-232 INTERFACE
91
92
RS-232
96
RS232
122
BLADDER
CONTROL UNIT
29
94
MATTRESS
93
BRAKE SWITCH
116
M
HEAD SECTION
117
M
KNEE SECTION
118
M
HEAD LIFT
119
M
FOOT LIFT

FIG.2B

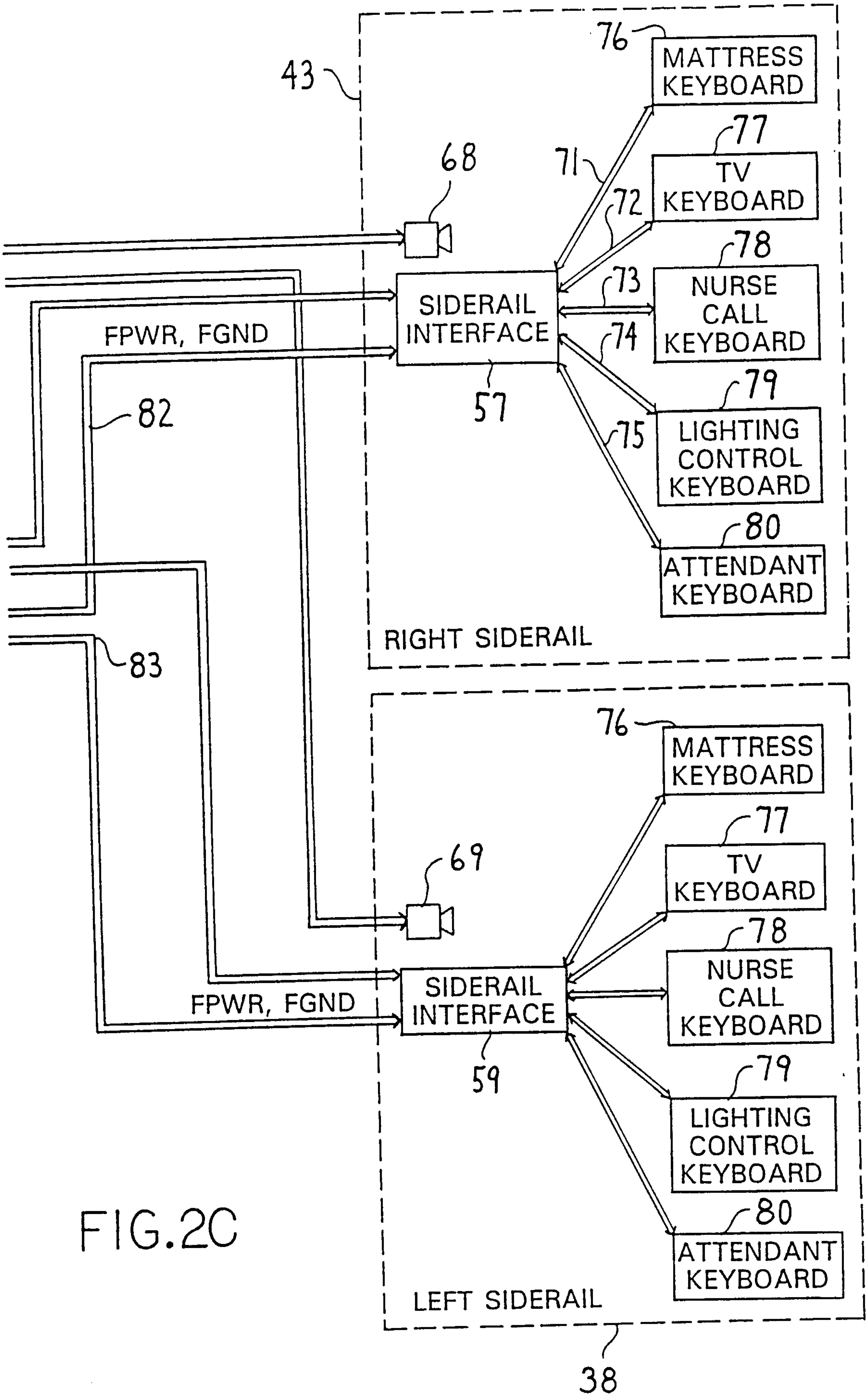
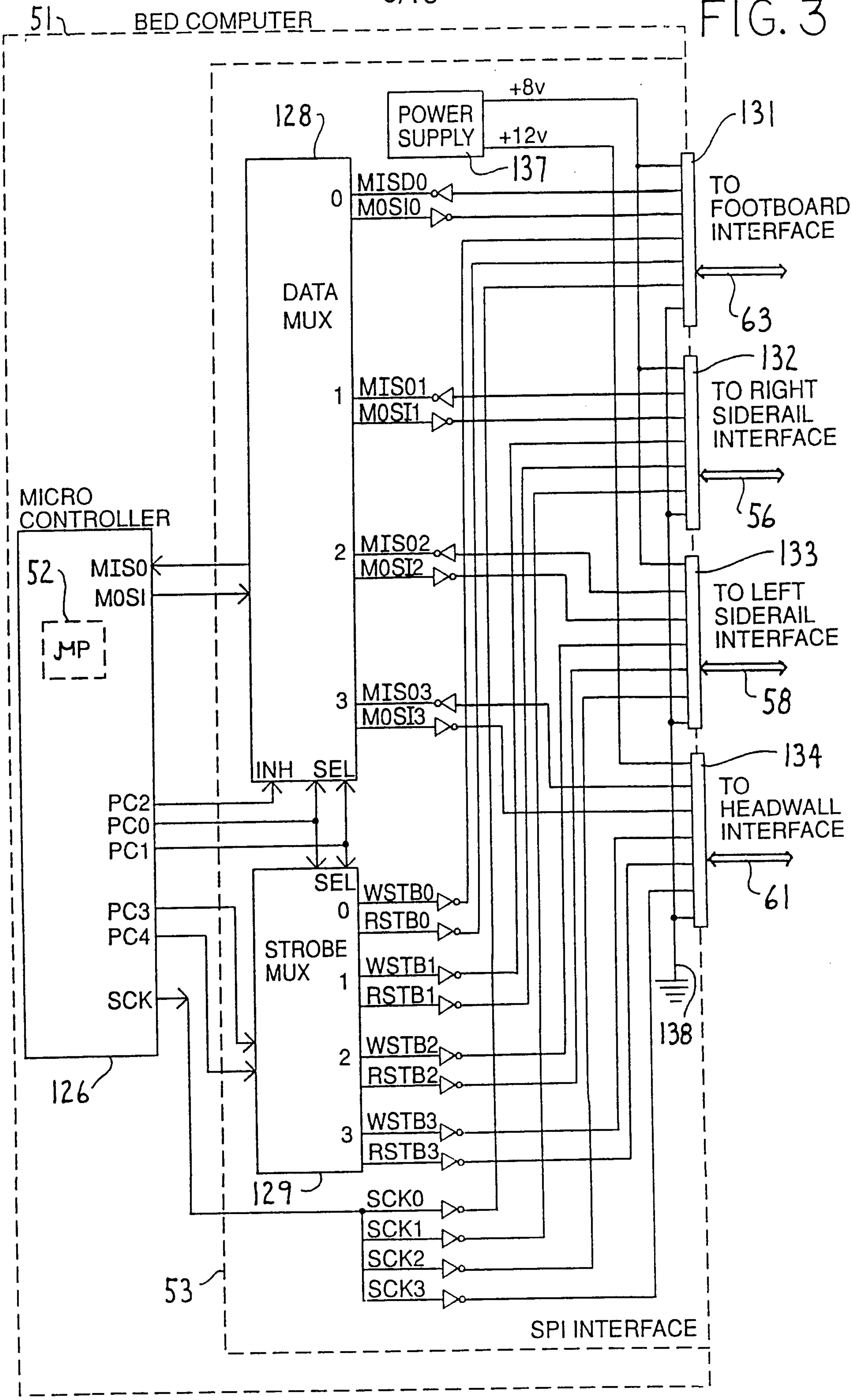

43
76
MATTRESS KEYBOARD
77
TV KEYBOARD
68
71
72
78
SIDERAIL INTERFACE
73
NURSE CALL KEYBOARD
FPWR, FGND
74
57
79
LIGHTING CONTROL KEYBOARD
82
75
80
ATTENDANT KEYBOARD
RIGHT SIDERAIL
83
76
MATTRESS KEYBOARD
77
TV KEYBOARD
69
78
SIDERAIL INTERFACE
NURSE CALL KEYBOARD
FPWR, FGND
59
79
LIGHTING CONTROL KEYBOARD
80
ATTENDANT KEYBOARD
LEFT SIDERAIL
38

FIG.2C

FIG. 3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BED COMPUTER
128
POWER SUPPLY
+8v
+12v
137
131
TO FOOTBOARD INTERFACE
63
DATA MUX
0
MISD0
M0SI0
1
MIS01
M0SI1
132
TO RIGHT SIDERAIL INTERFACE
56
MICRO CONTROLLER
52
MIS0
M0SI
MP
2
MIS02
M0SI2
133
TO LEFT SIDERAIL INTERFACE
58
3
MIS03
M0SI3
INH
SEL
134
TO HEADWALL INTERFACE
61
PC2
PC0
PC1
PC3
PC4
SCK
SEL
STROBE MUX
WSTB0
RSTB0
WSTB1
RSTB1
WSTB2
RSTB2
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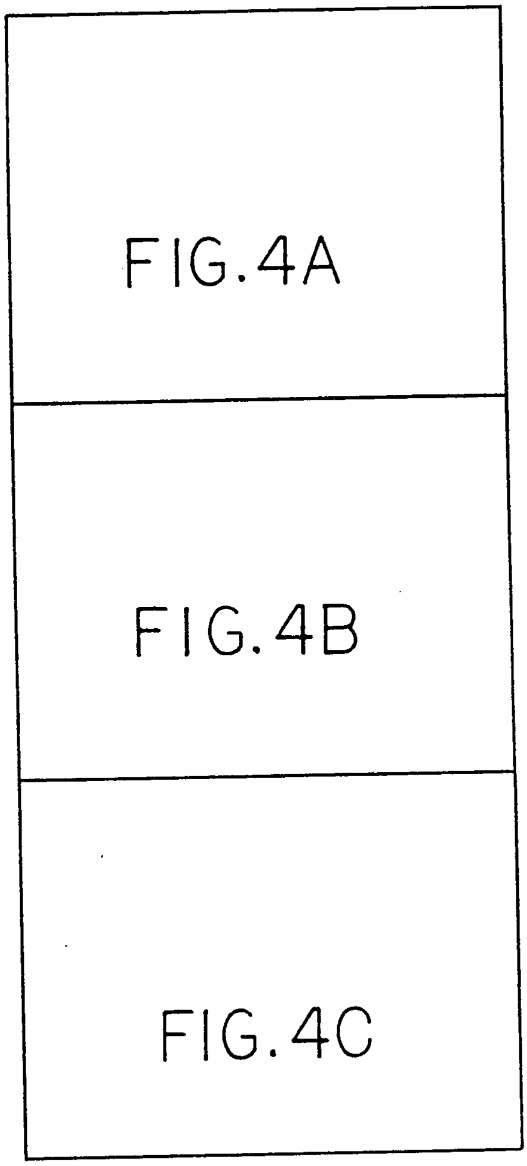
129
SCK0
SCK1
SCK2
SCK3
53
SPI INTERFACE

FIG. 4



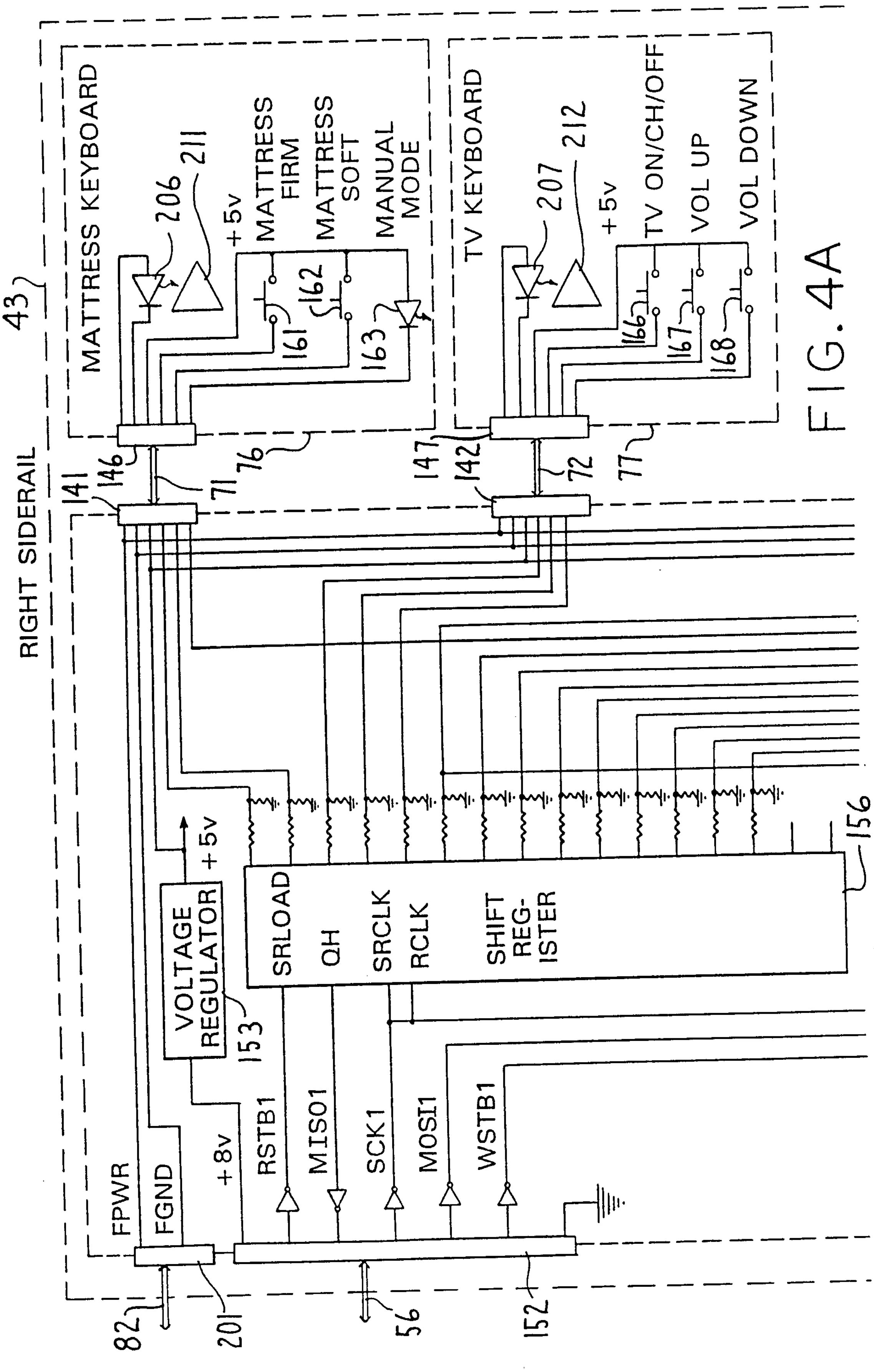

43
MATTRESS KEYBOARD
206
211
+5v
MATTRESS FIRM
MATTRESS SOFT
MANUAL MODE
161
162
163
TV KEYBOARD
207
212
+5v
TV ON/CH/OFF
VOL UP
VOL DOWN
166
167
168
146
71
76
147
142
72
77
141
RIGHT SIDERAIL
VOLTAGE REGULATOR
153
+5v
SRLOAD
QH
SRCLK
RCLK
SHIFT REG-ISTER
156
FPWR
FGND
+8v
RSTB1
MISO1
SCK1
MOSI1
WSTB1
82
201
56
152

FIG. 4A

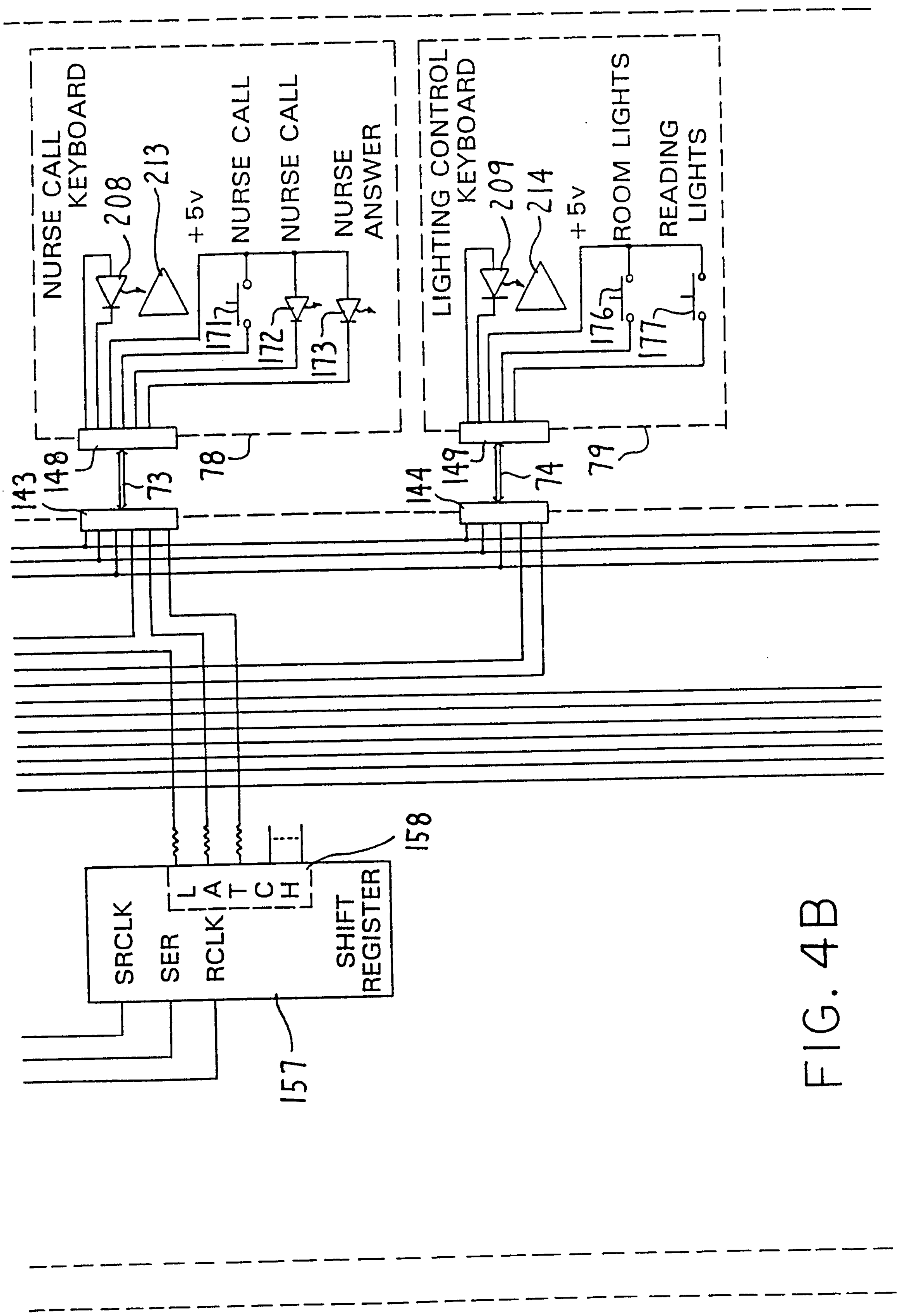

NURSE CALL KEYBOARD
208
213
+5v
NURSE CALL
NURSE CALL
NURSE ANSWER
171
172
173
LIGHTING CONTROL KEYBOARD
209
214
+5v
ROOM LIGHTS
READING LIGHTS
176
177
78
79
143
148
73
144
149
74
SRCLK
SER
RCLK
LATCH
SHIFT REGISTER
157
158

FIG. 4B

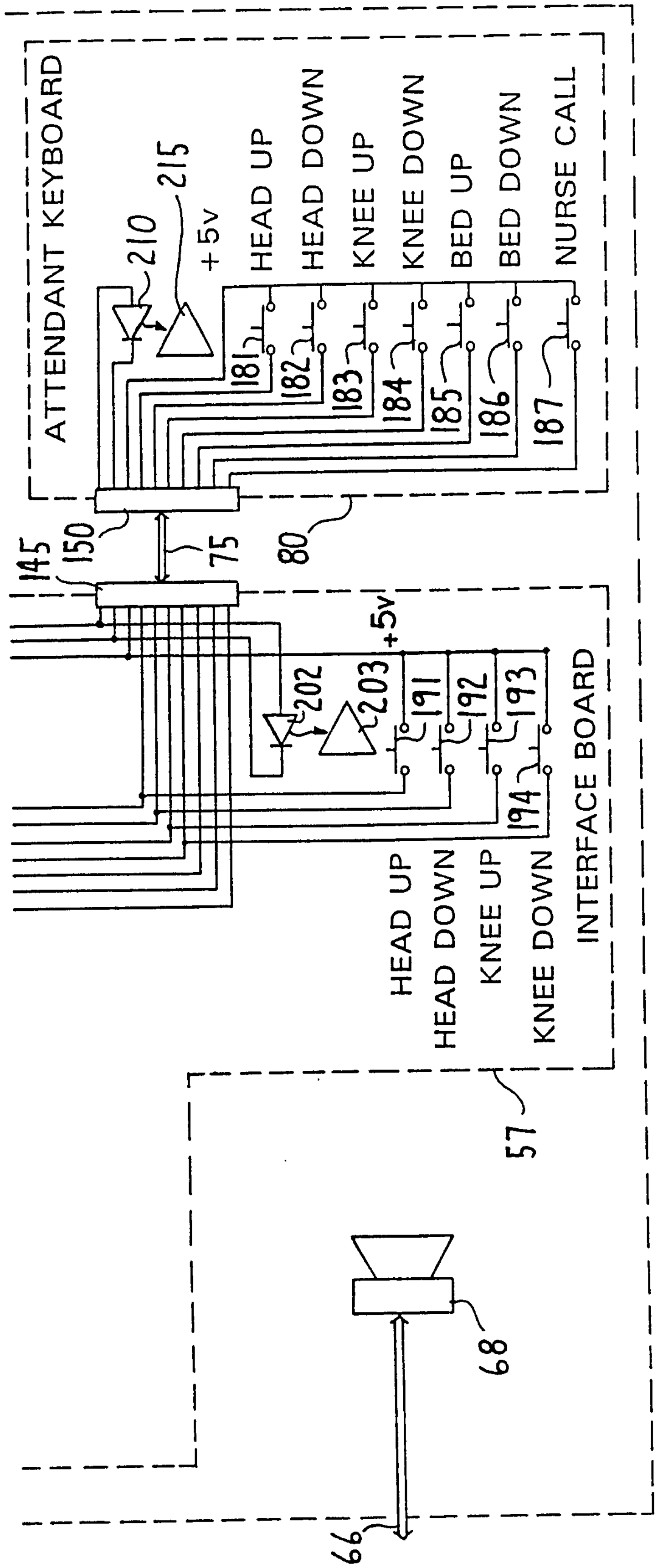

ATTENDANT KEYBOARD
210
215
+5v
HEAD UP
HEAD DOWN
KNEE UP
KNEE DOWN
BED UP
BED DOWN
NURSE CALL
181
182
183
184
185
186
187
80
150
145
75
202
203
+5v
191
192
193
194
HEAD UP
HEAD DOWN
KNEE UP
KNEE DOWN
INTERFACE BOARD
57
68
66

FIG. 4C

FIG. 5

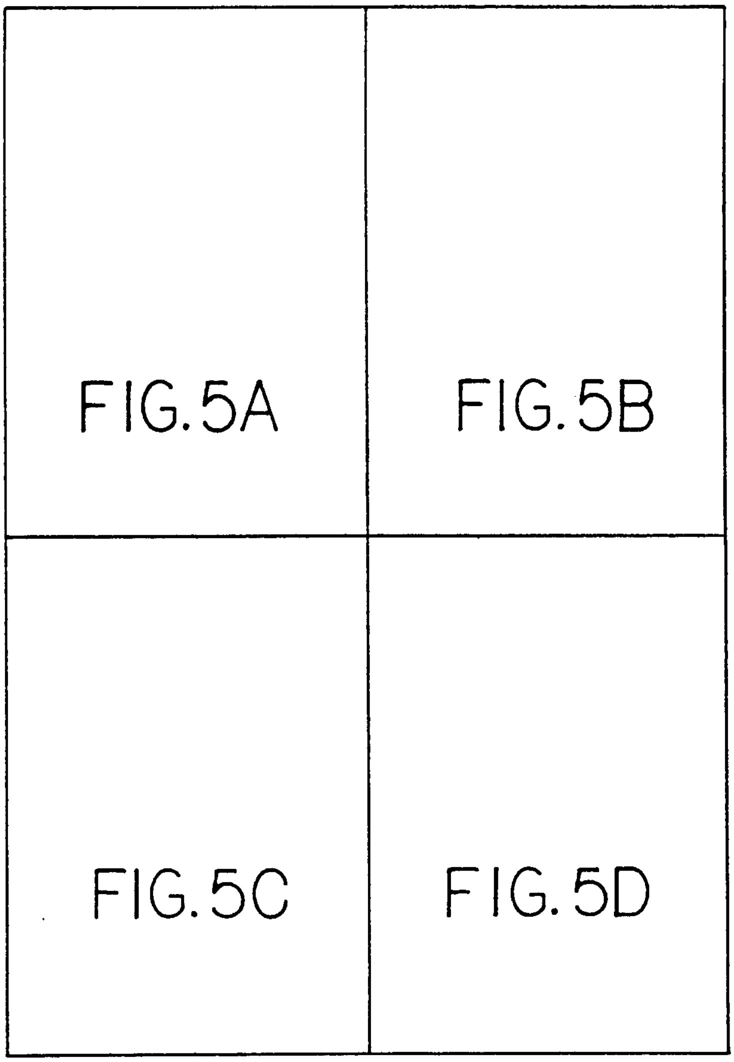


FIG. 5A

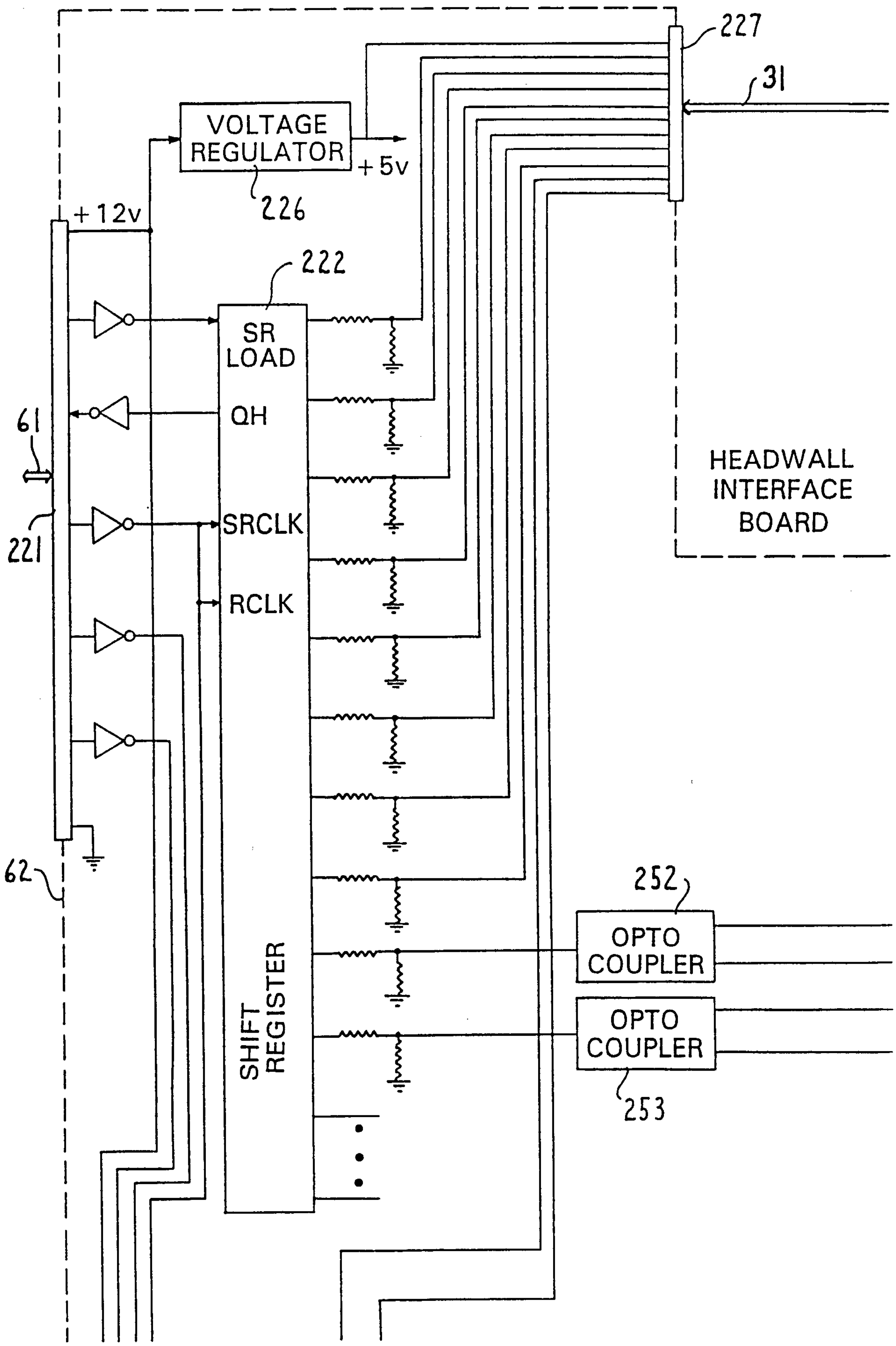
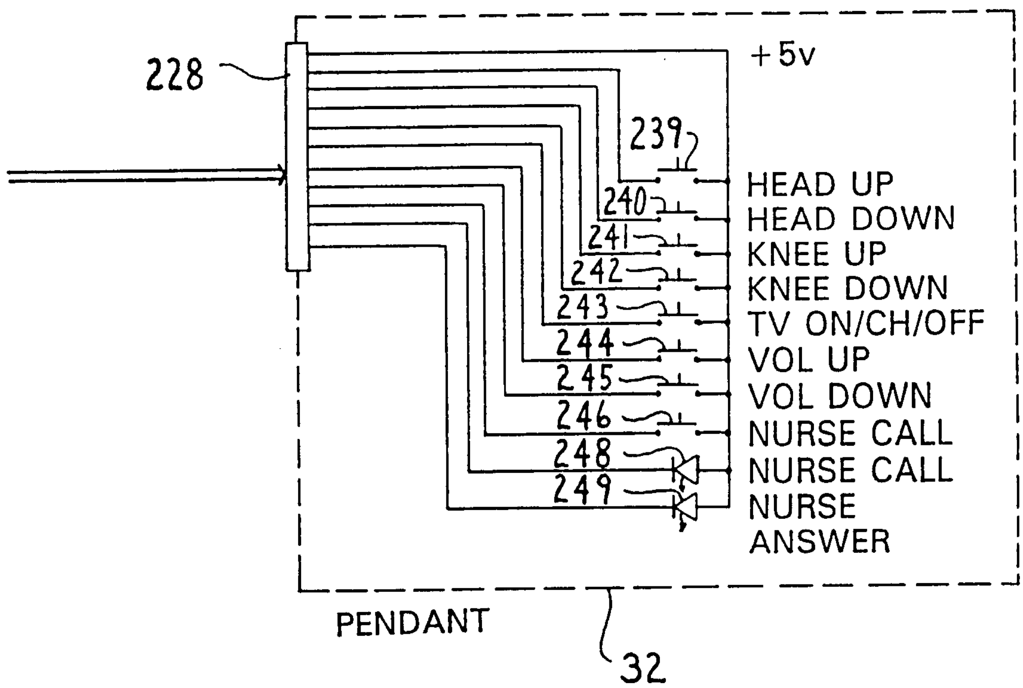

227
31
VOLTAGE REGULATOR
+5v
226
+12v
222
SR LOAD
QH
61
SRCLK
221
RCLK
HEADWALL INTERFACE BOARD
62
252
OPTO COUPLER
OPTO COUPLER
253
SHIFT REGISTER

FIG. 5B


228
+5v
239
240
241
242
243
244
245
246
248
249
HEAD UP
HEAD DOWN
KNEE UP
KNEE DOWN
TV ON/CH/OFF
VOL UP
VOL DOWN
NURSE CALL
NURSE CALL
NURSE ANSWER
PENDANT
32

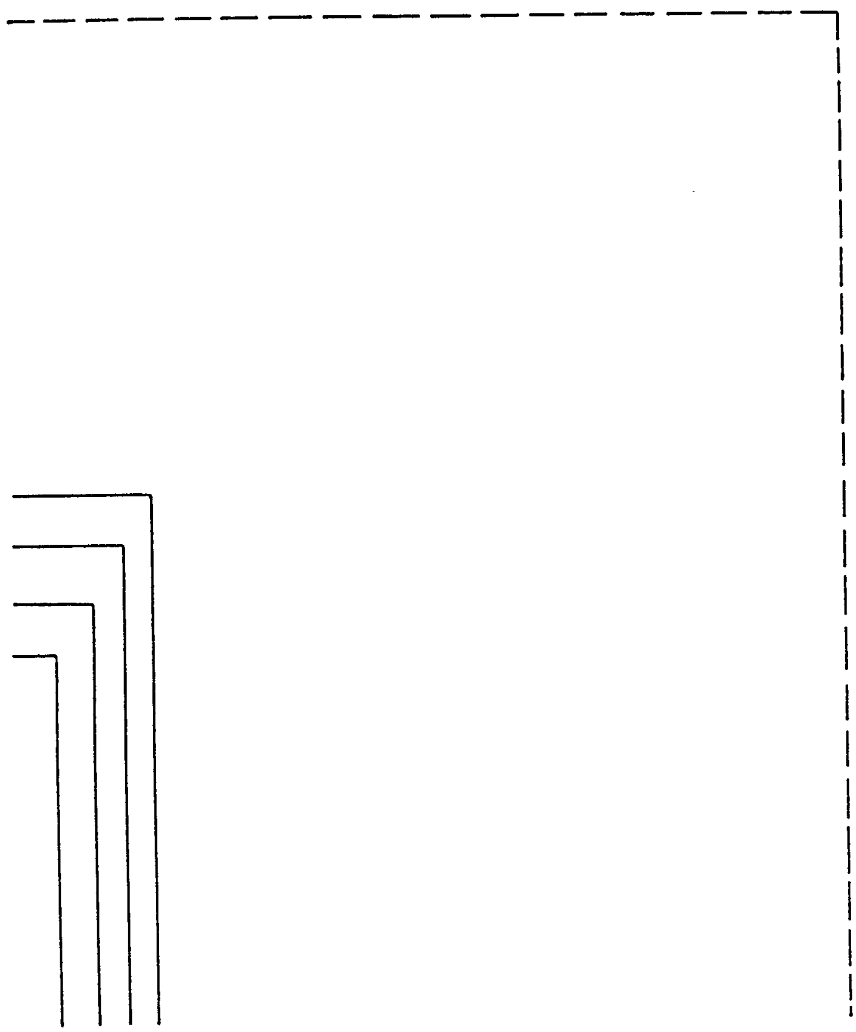


FIG. 5C

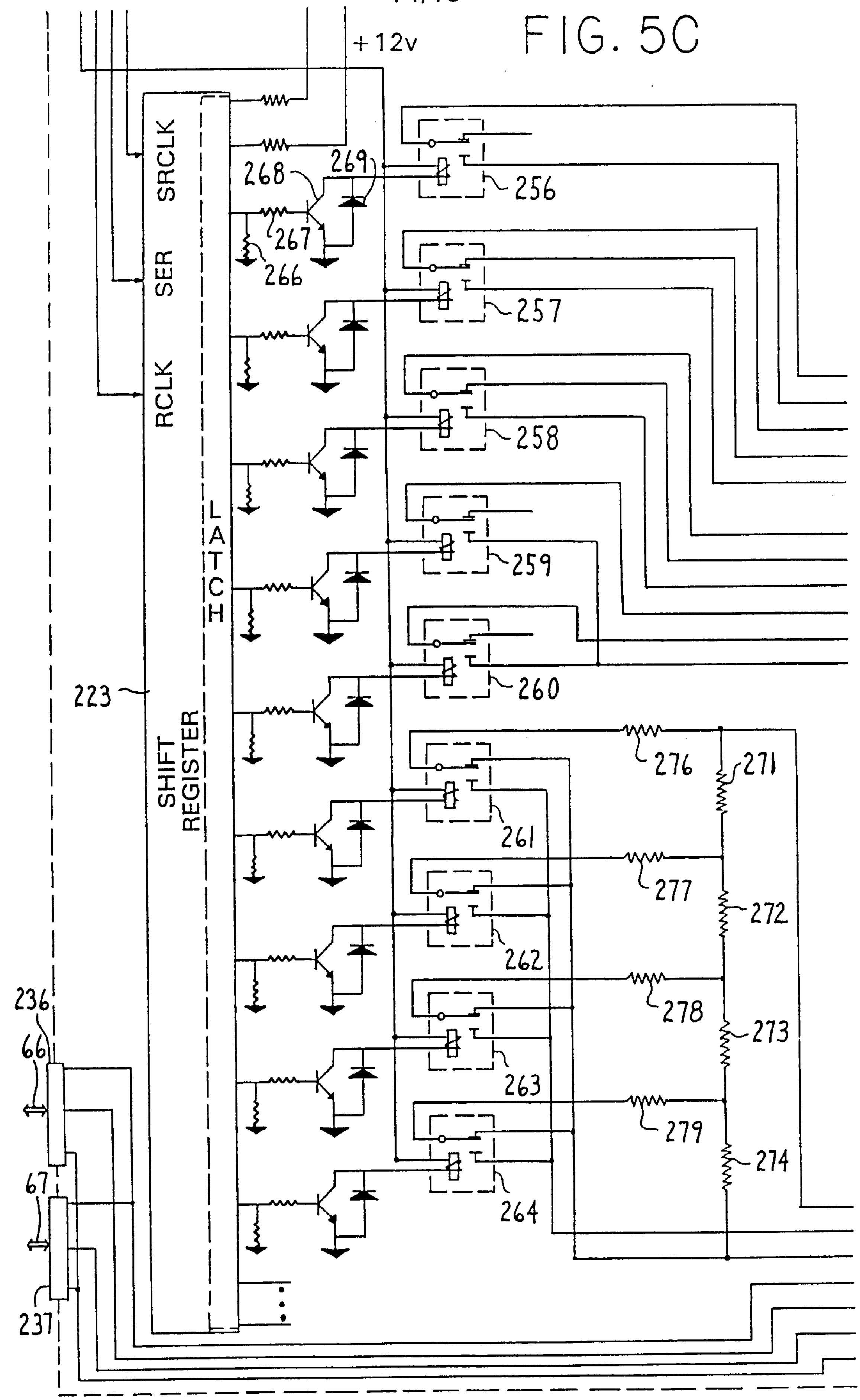
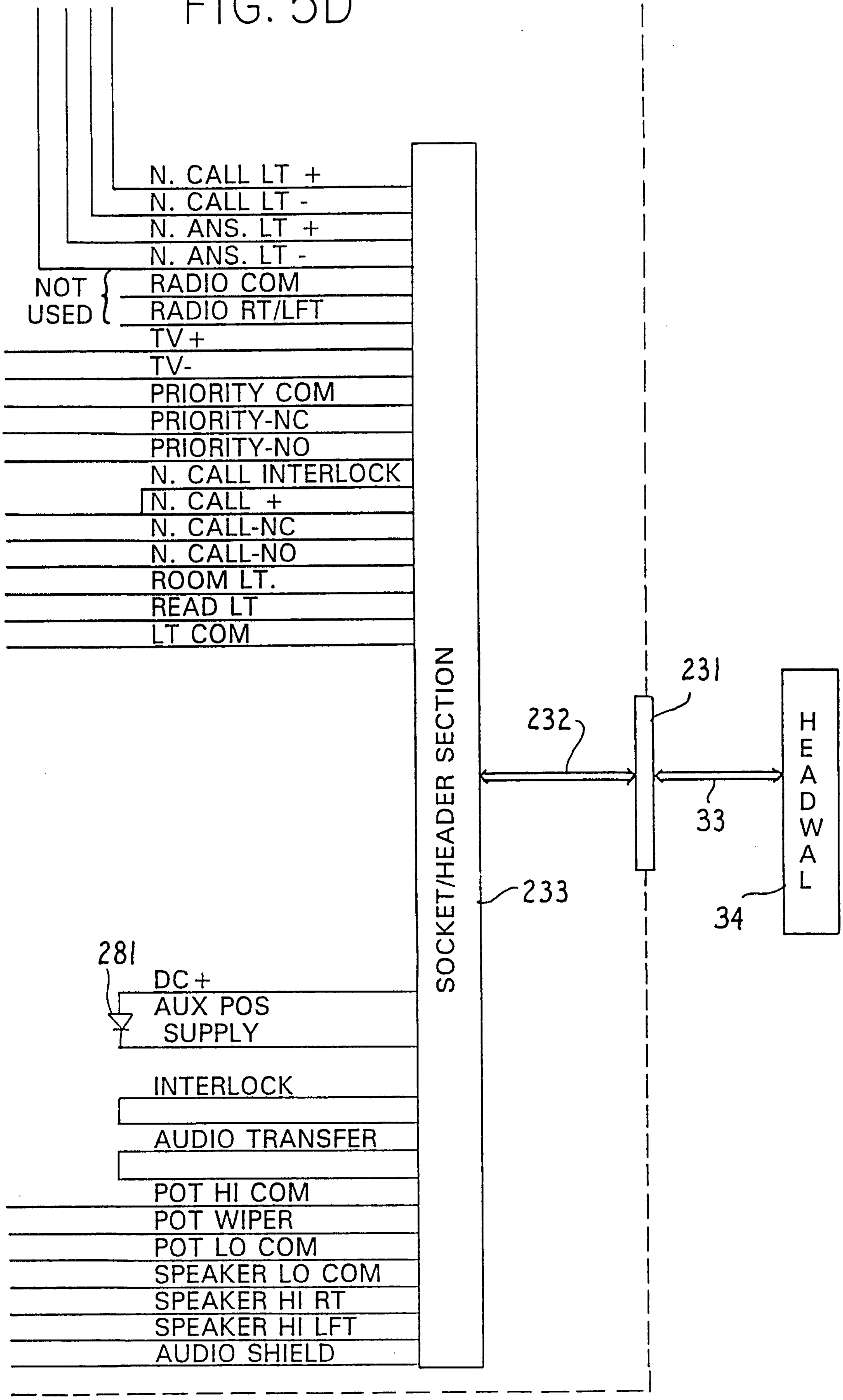

+12v
SRCLK
SER
RCLK
LATCH
SHIFT REGISTER
223
236
66
67
237
256
257
258
259
260
261
262
263
264
266
267
268
269
271
272
273
274
276
277
278
279

FIG. 5D


N. CALL LT +
N. CALL LT -
N. ANS. LT +
N. ANS. LT -
NOT USED
RADIO COM
RADIO RT/LFT
TV+
TV-
PRIORITY COM
PRIORITY-NC
PRIORITY-NO
N. CALL INTERLOCK
N. CALL +
N. CALL-NC
N. CALL-NO
ROOM LT.
READ LT
LT COM
SOCKET/HEADER SECTION
231
232
33
233
34
HEADWAL
281
DC+
AUX POS SUPPLY
INTERLOCK
AUDIO TRANSFER
POT HI COM
POT WIPER
POT LO COM
SPEAKER LO COM
SPEAKER HI RT
SPEAKER HI LFT
AUDIO SHIELD

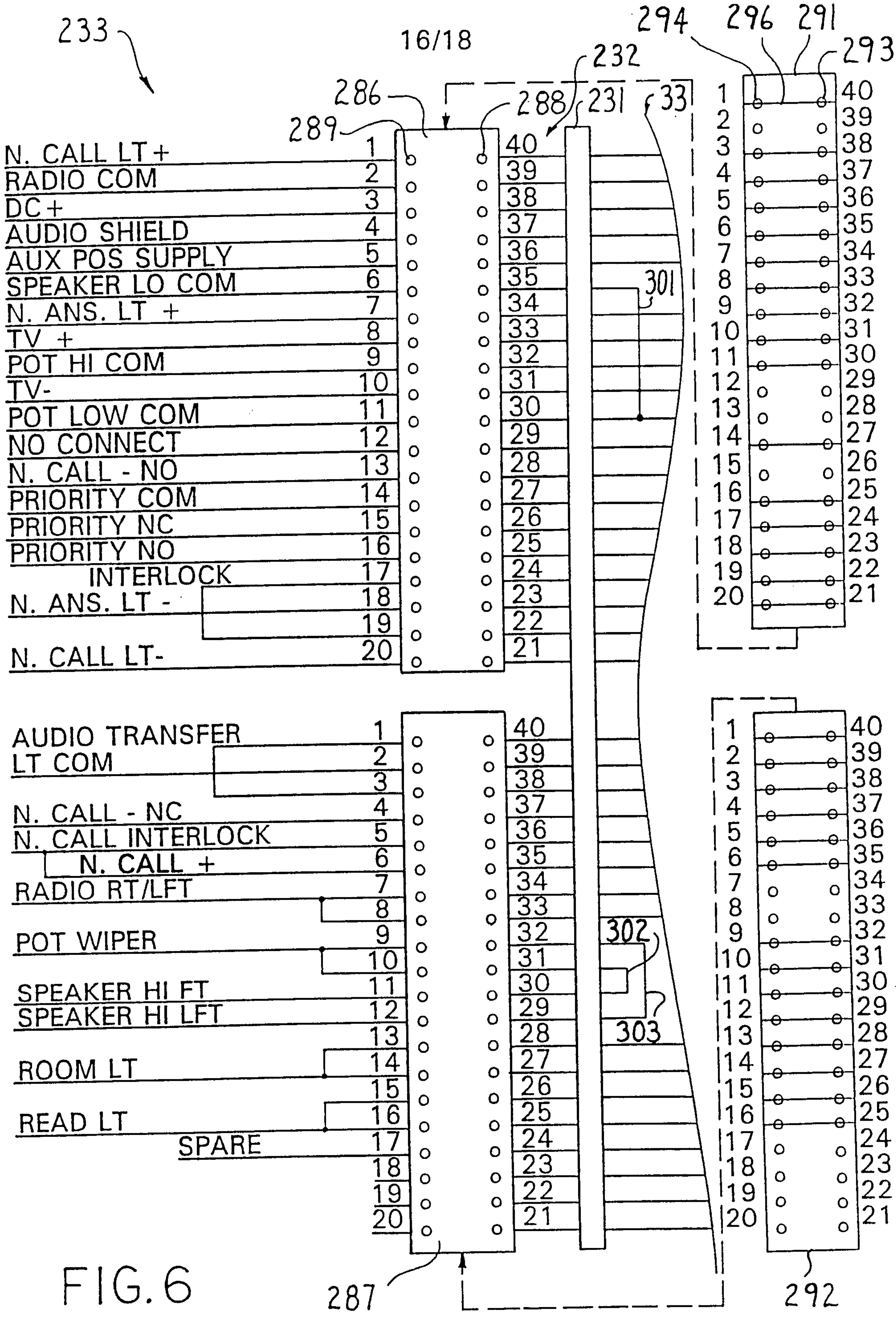

233
294
296
291
293
232
286
288
231
33
289
N. CALL LT+
RADIO COM
DC+
AUDIO SHIELD
AUX POS SUPPLY
SPEAKER LO COM
N. ANS. LT +
TV +
POT HI COM
TV-
POT LOW COM
NO CONNECT
N. CALL - NO
PRIORITY COM
PRIORITY NC
PRIORITY NO
INTERLOCK
N. ANS. LT -
N. CALL LT-
301
AUDIO TRANSFER
LT COM
N. CALL - NC
N. CALL INTERLOCK
N. CALL +
RADIO RT/LFT
POT WIPER
SPEAKER HI FT
SPEAKER HI LFT
ROOM LT
READ LT
SPARE
302
303
287
292

FIG. 6

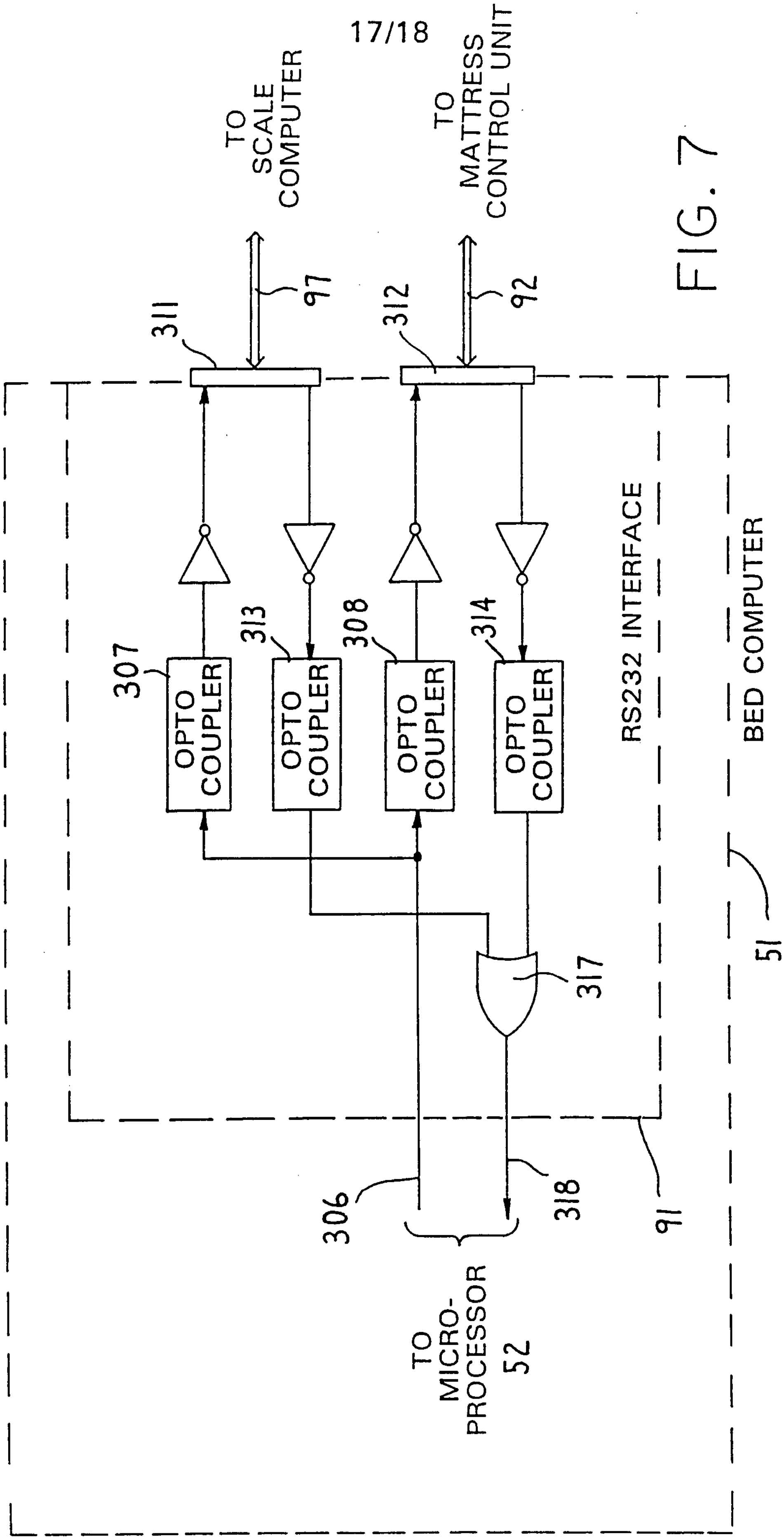

TO SCALE COMPUTER
97
TO MATTRESS CONTROL UNIT
92
311
312
307
313
308
314
OPTO COUPLER
OPTO COUPLER
OPTO COUPLER
OPTO COUPLER
RS232 INTERFACE
BED COMPUTER
317
51
306
318
91
TO MICRO-PROCESSOR 52

FIG. 7

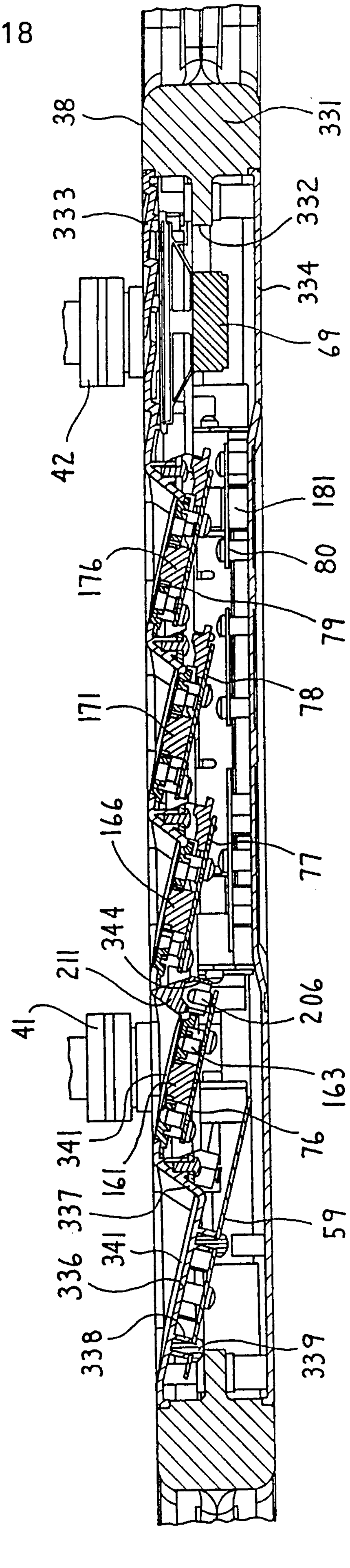

38
331
333
332
334
69
42
181
80
176
79
78
171
166
77
344
211
206
41
163
341
76
161
337
59
341
336
338
339

FIG. 8