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Dixon et al.

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(54) **PATIENT POSITION DETECTION APPARATUS FOR A BED**

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(22) Filed: **Nov. 19, 2001**

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Related U.S. Application Data

(60) Continuation of application No. 09/737,111, filed on Dec. 14, 2000, now Pat. No. 6,320,510, which is a division of application No. 09/264,174, filed on Mar. 5, 1999, now Pat. No. 6,208,250.

(51) **Int. Cl.**[7] **G08B 23/00**

(52) **U.S. Cl.** **340/573.1**; 340/5.1; 340/562; 340/572.1; 340/664; 340/666; 340/667; 340/686.1; 5/618; 5/624

(58) **Field of Search** 340/573.1, 5.1, 340/562, 572.1, 664, 666, 667, 686.1; 5/618, 624

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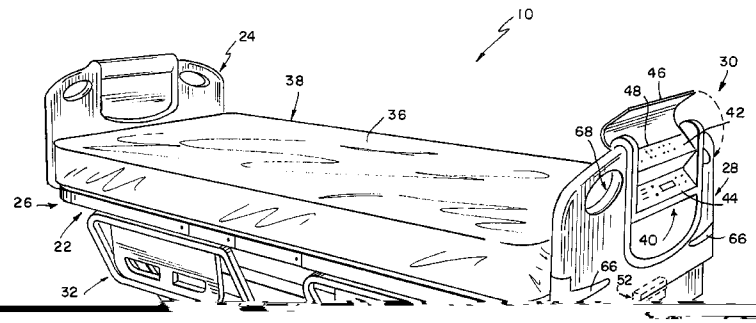
(57) **ABSTRACT**

An apparatus for supporting a patient comprises a frame, a mattress supported by the frame, and a patient position detection system including an alarm and at least one sensor configured to detect a position of the patient relative to the mattress. The patient position detection system has at least three different modes of operation.

45 Claims, 14 Drawing Sheets



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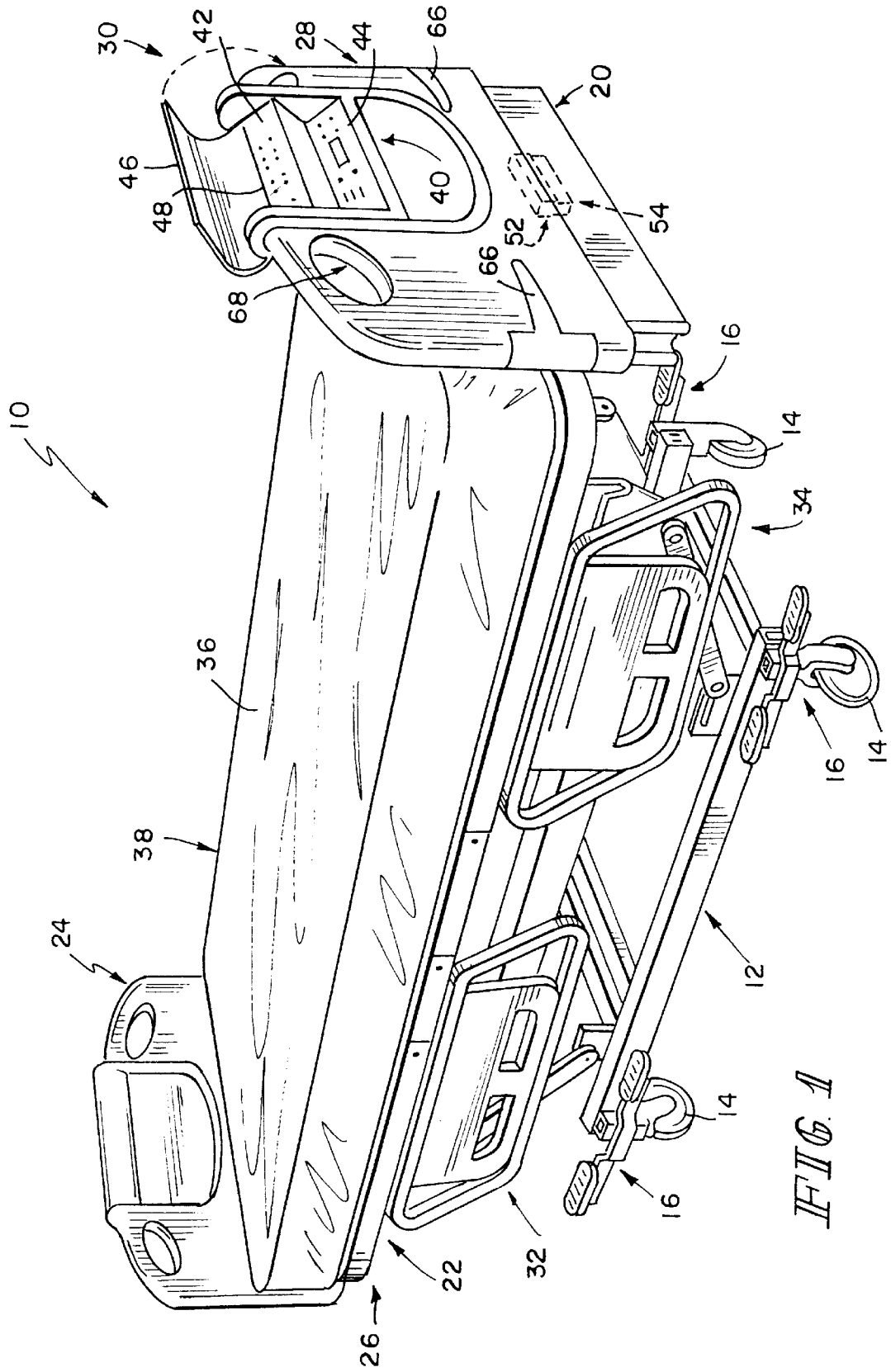
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FIG. 1

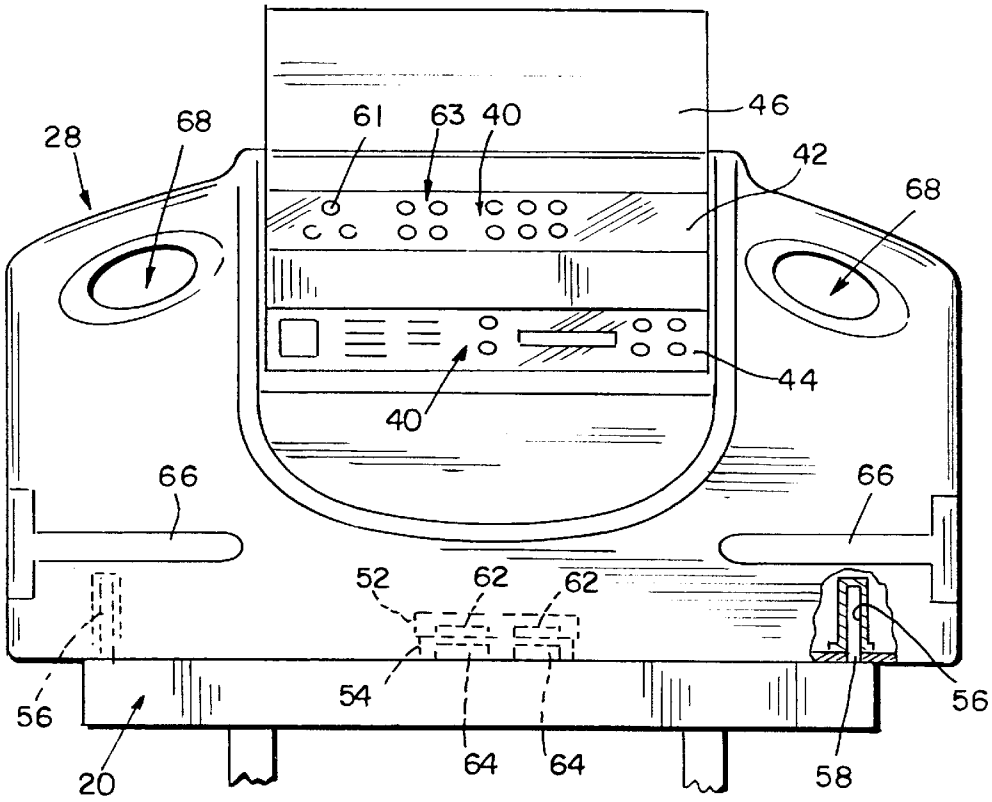
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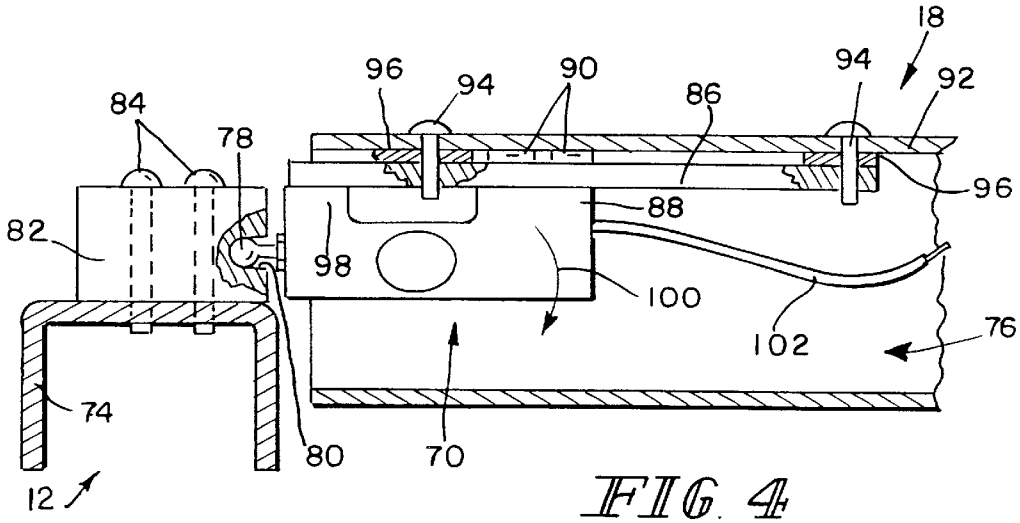
FIG. 2


18
96
94
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78
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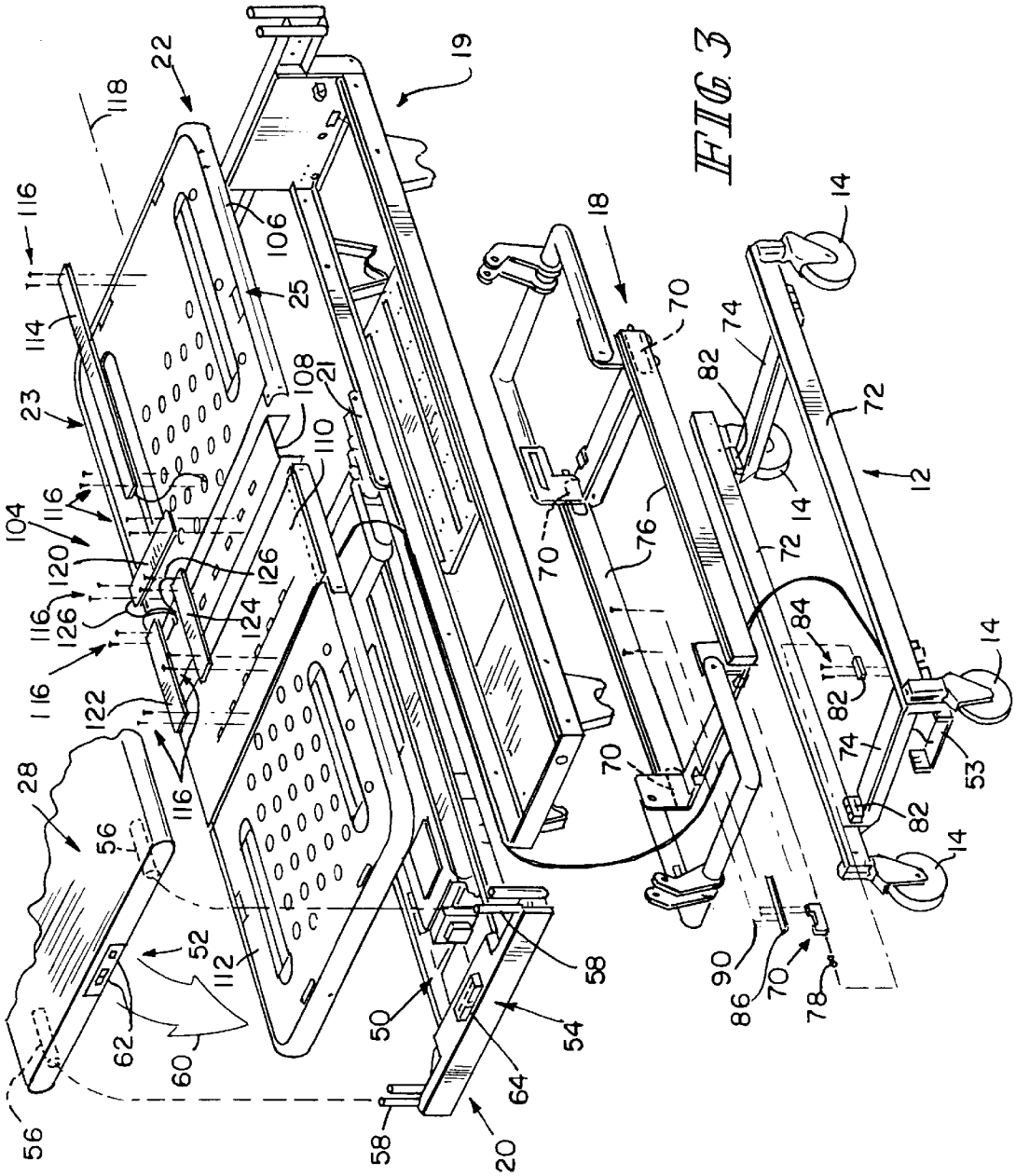
88
82
98
100
102
76
74
80
70
12

FIG. 4


22
19
118
116
106
25
114
108
21
23
110
104
120
126
124
122
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52
112
62
60
50
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18
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84
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90
86
78

FIG 3

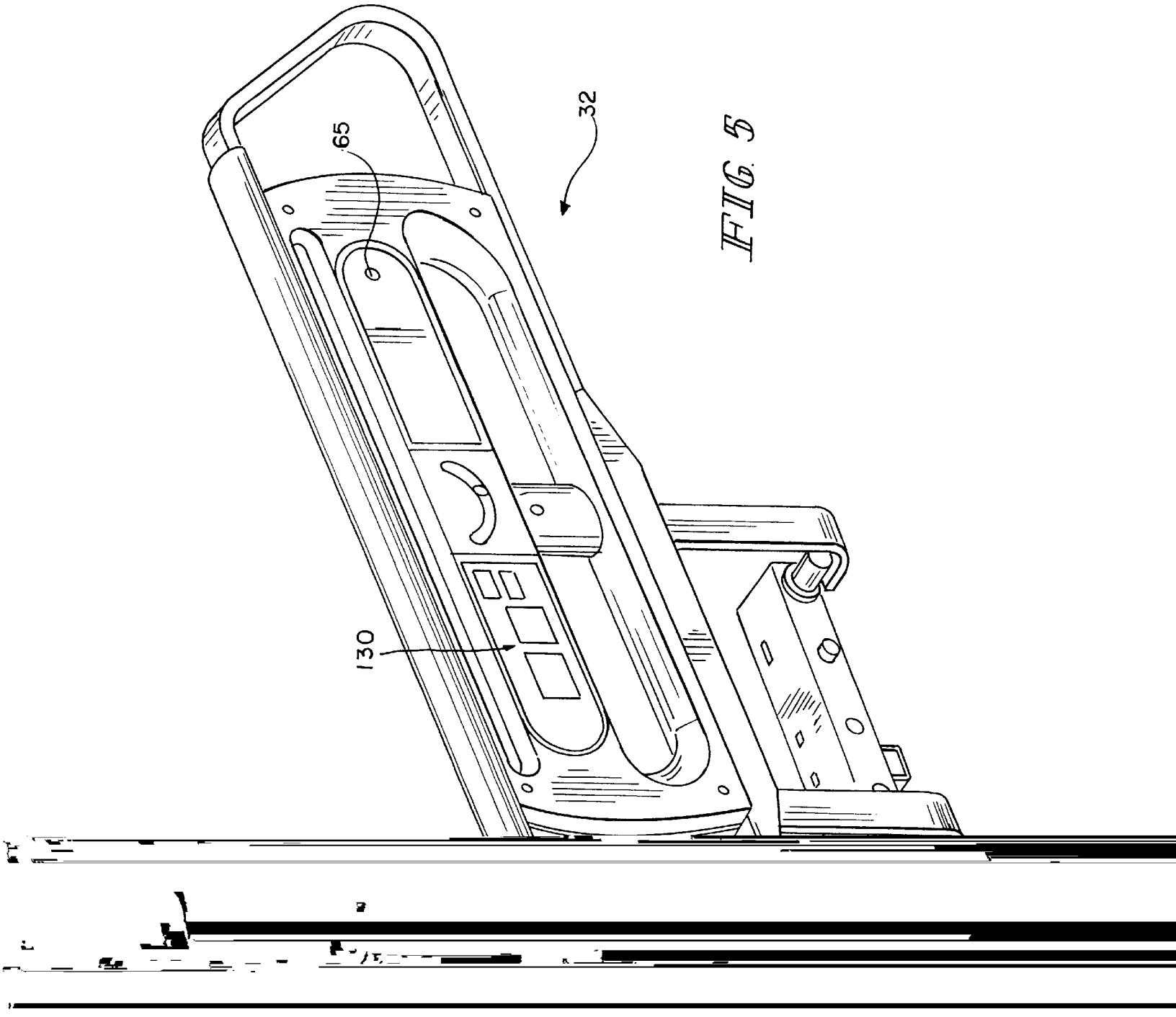
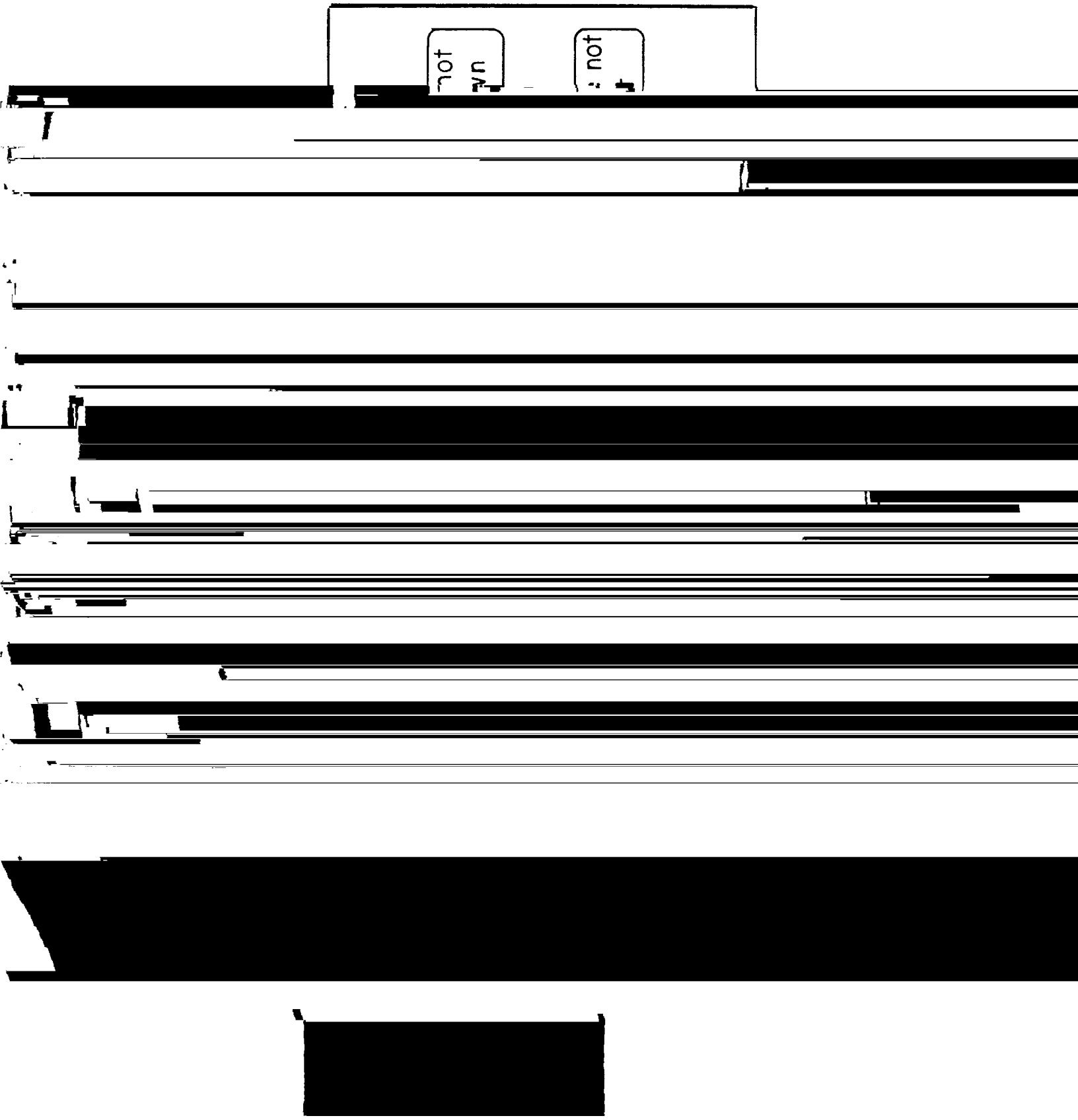


FIG 5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not

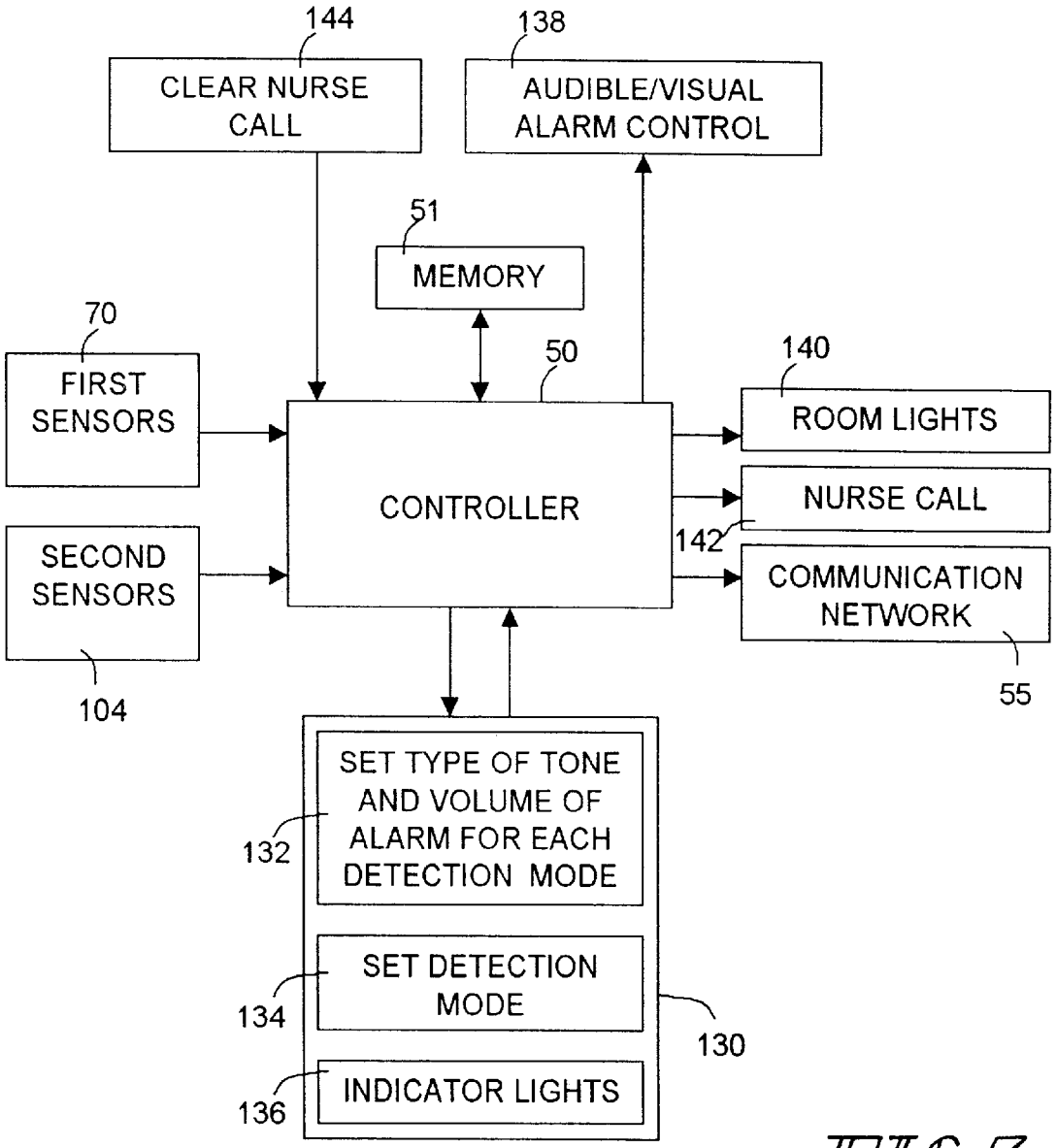

144
CLEAR NURSE CALL
138
AUDIBLE/VISUAL ALARM CONTROL
51
MEMORY
70
FIRST SENSORS
50
140
ROOM LIGHTS
CONTROLLER
NURSE CALL
142
SECOND SENSORS
COMMUNICATION NETWORK
104
55
SET TYPE OF TONE AND VOLUME OF ALARM FOR EACH DETECTION MODE
132
SET DETECTION MODE
134
130
INDICATOR LIGHTS
136

FIG. 1

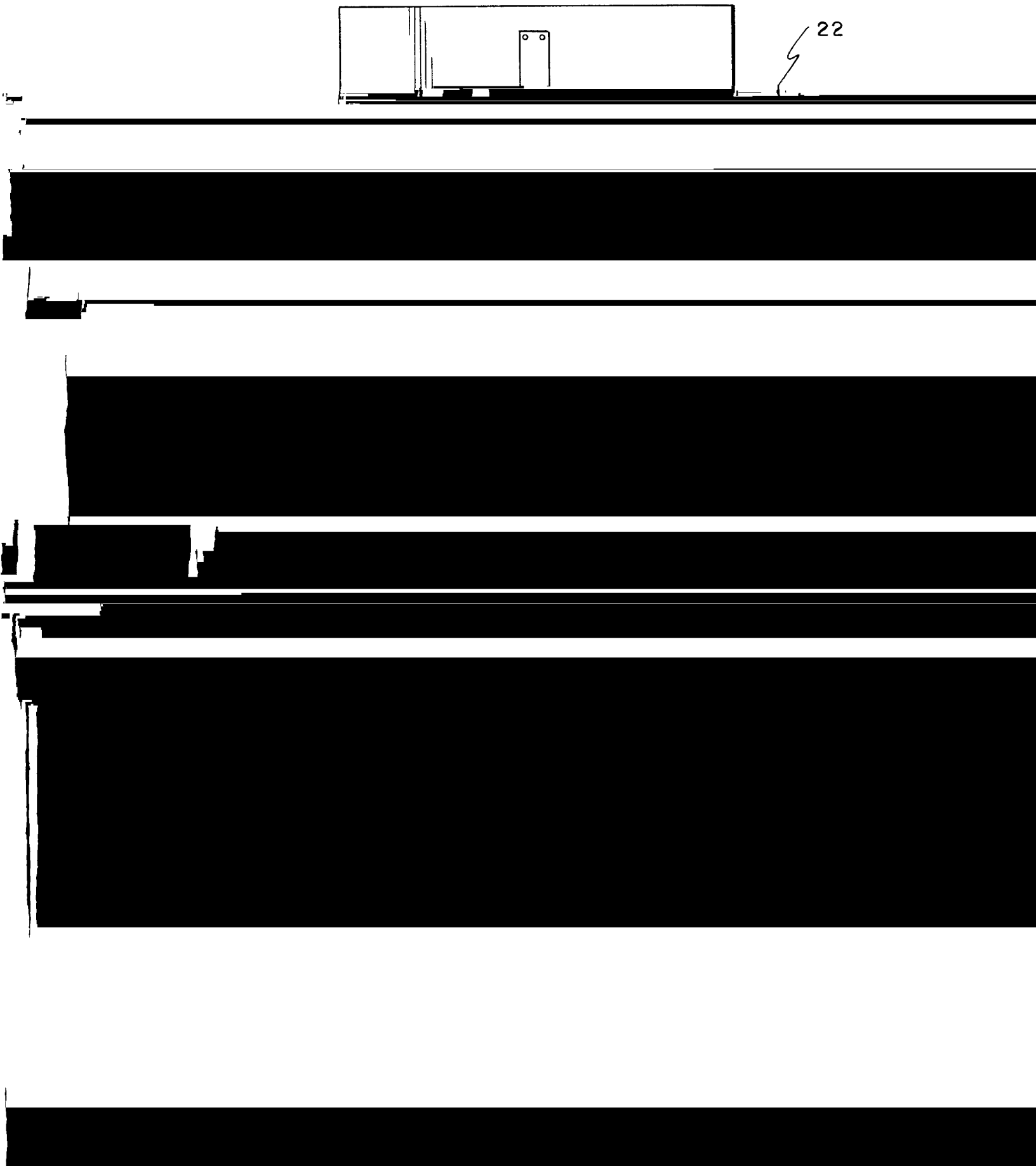
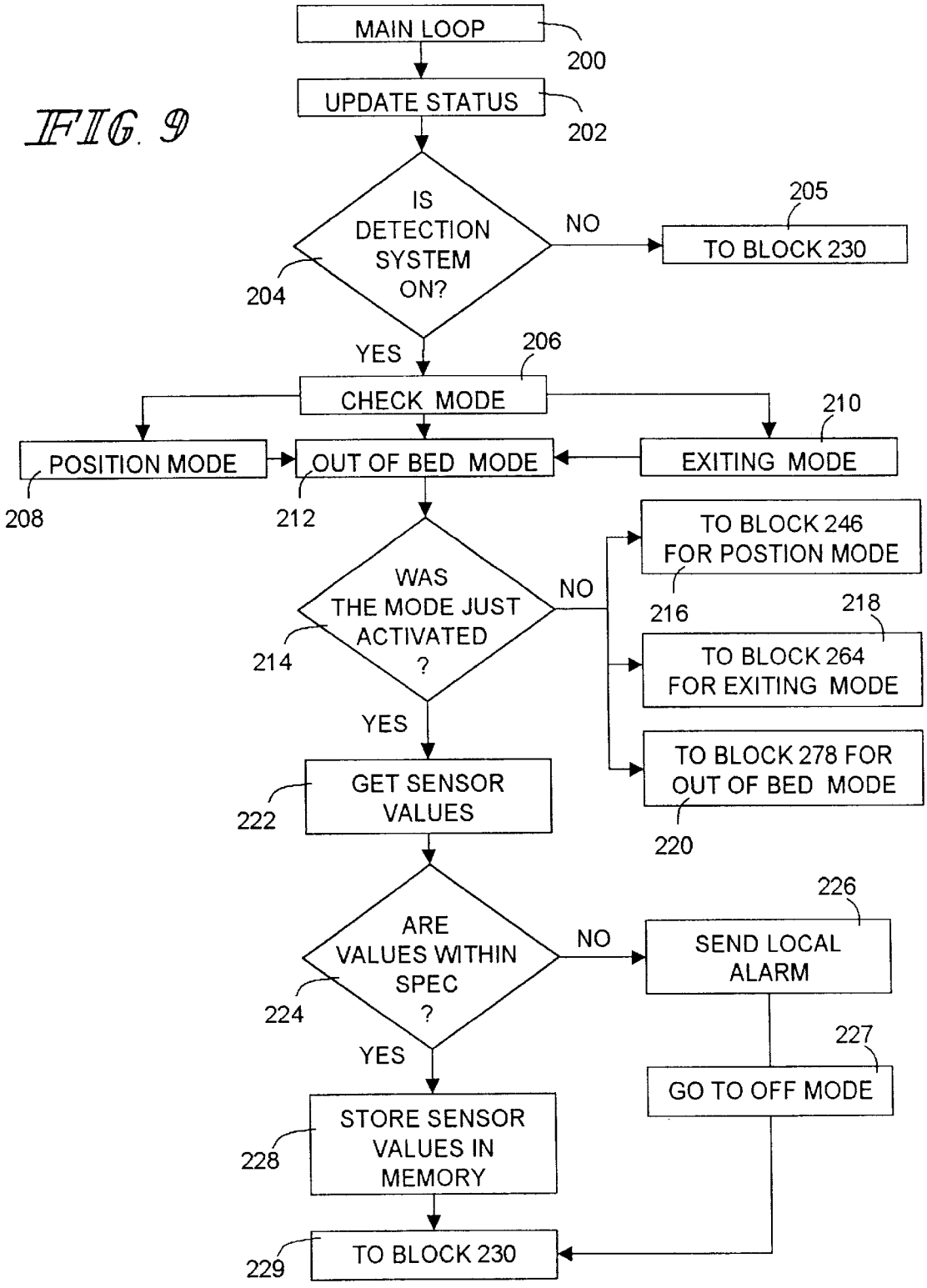

22

FIG. 9


MAIN LOOP
200
UPDATE STATUS
202
IS DETECTION SYSTEM ON?
204
NO
205
TO BLOCK 230
YES
206
CHECK MODE
210
POSITION MODE
208
OUT OF BED MODE
212
EXITING MODE
WAS THE MODE JUST ACTIVATED ?
214
NO
TO BLOCK 246 FOR POSTION MODE
216
218
TO BLOCK 264 FOR EXITING MODE
TO BLOCK 278 FOR OUT OF BED MODE
220
YES
GET SENSOR VALUES
222
ARE VALUES WITHIN SPEC ?
224
NO
226
SEND LOCAL ALARM
227
GO TO OFF MODE
YES
STORE SENSOR VALUES IN MEMORY
228
TO BLOCK 230
229

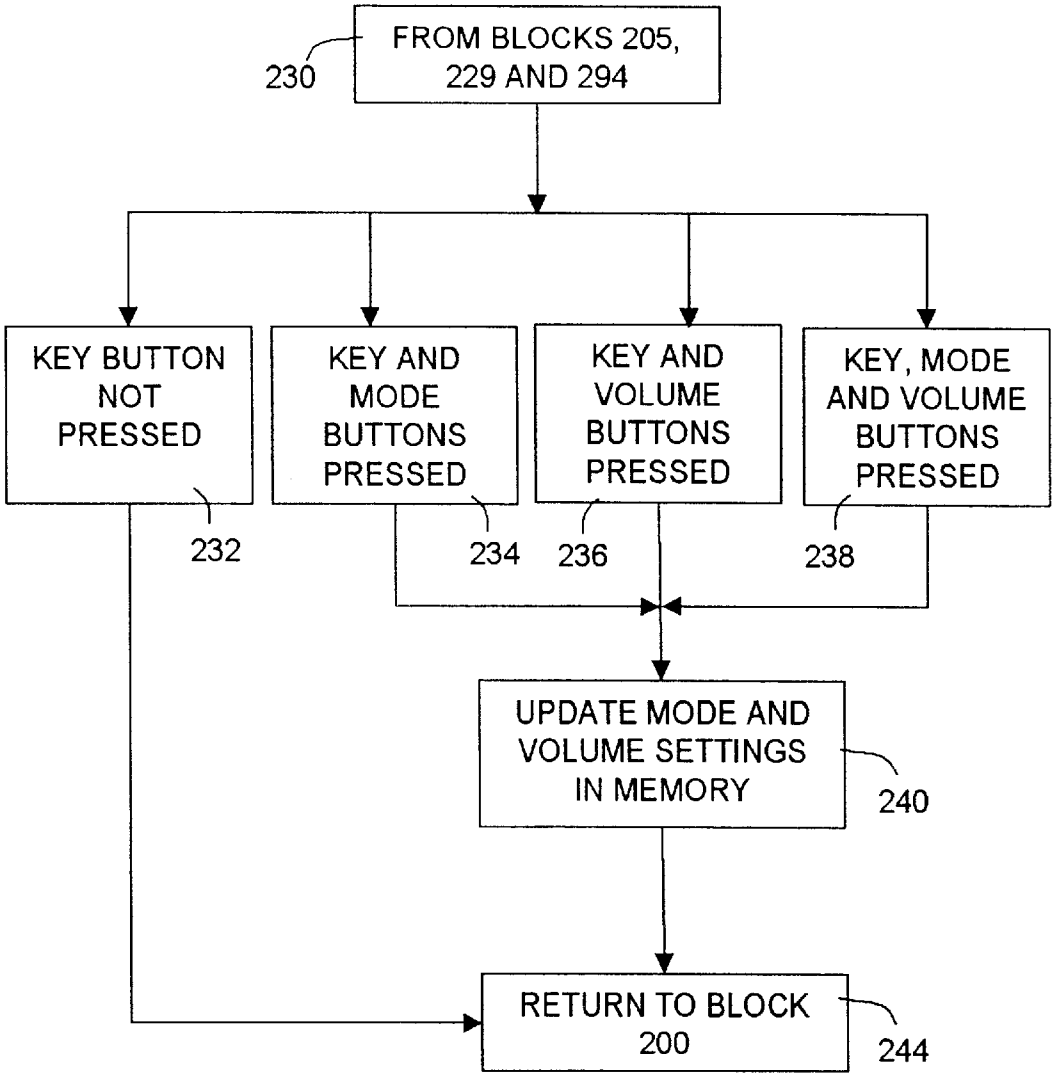

230
FROM BLOCKS 205, 229 AND 294
KEY BUTTON NOT PRESSED
KEY AND MODE BUTTONS PRESSED
KEY AND VOLUME BUTTONS PRESSED
KEY, MODE AND VOLUME BUTTONS PRESSED
232
234
236
238
UPDATE MODE AND VOLUME SETTINGS IN MEMORY
240
RETURN TO BLOCK 200
244

FIG. 10

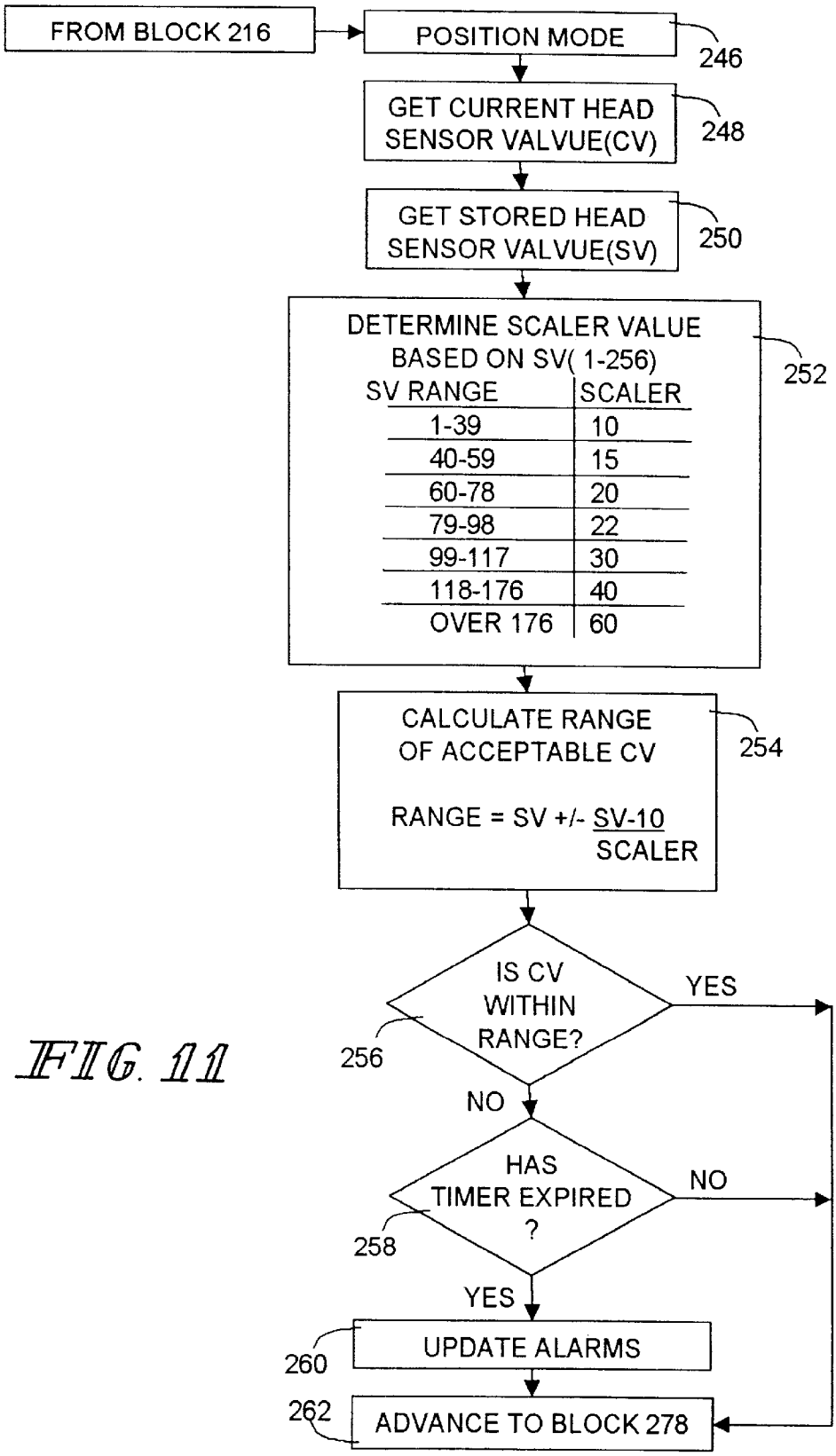

FROM BLOCK 216
POSITION MODE
246
GET CURRENT HEAD SENSOR VALVUE(CV)
248
GET STORED HEAD SENSOR VALVUE(SV)
250
DETERMINE SCALER VALUE BASED ON SV(1-256)
252
SV RANGE | SCALER
1-39 | 10
40-59 | 15
60-78 | 20
79-98 | 22
99-117 | 30
118-176 | 40
OVER 176 | 60
CALCULATE RANGE OF ACCEPTABLE CV
254
RANGE = SV +/- SV-10 / SCALER
IS CV WITHIN RANGE?
256
YES
NO
HAS TIMER EXPIRED ?
258
NO
YES
UPDATE ALARMS
260
ADVANCE TO BLOCK 278
262

FIG. 11

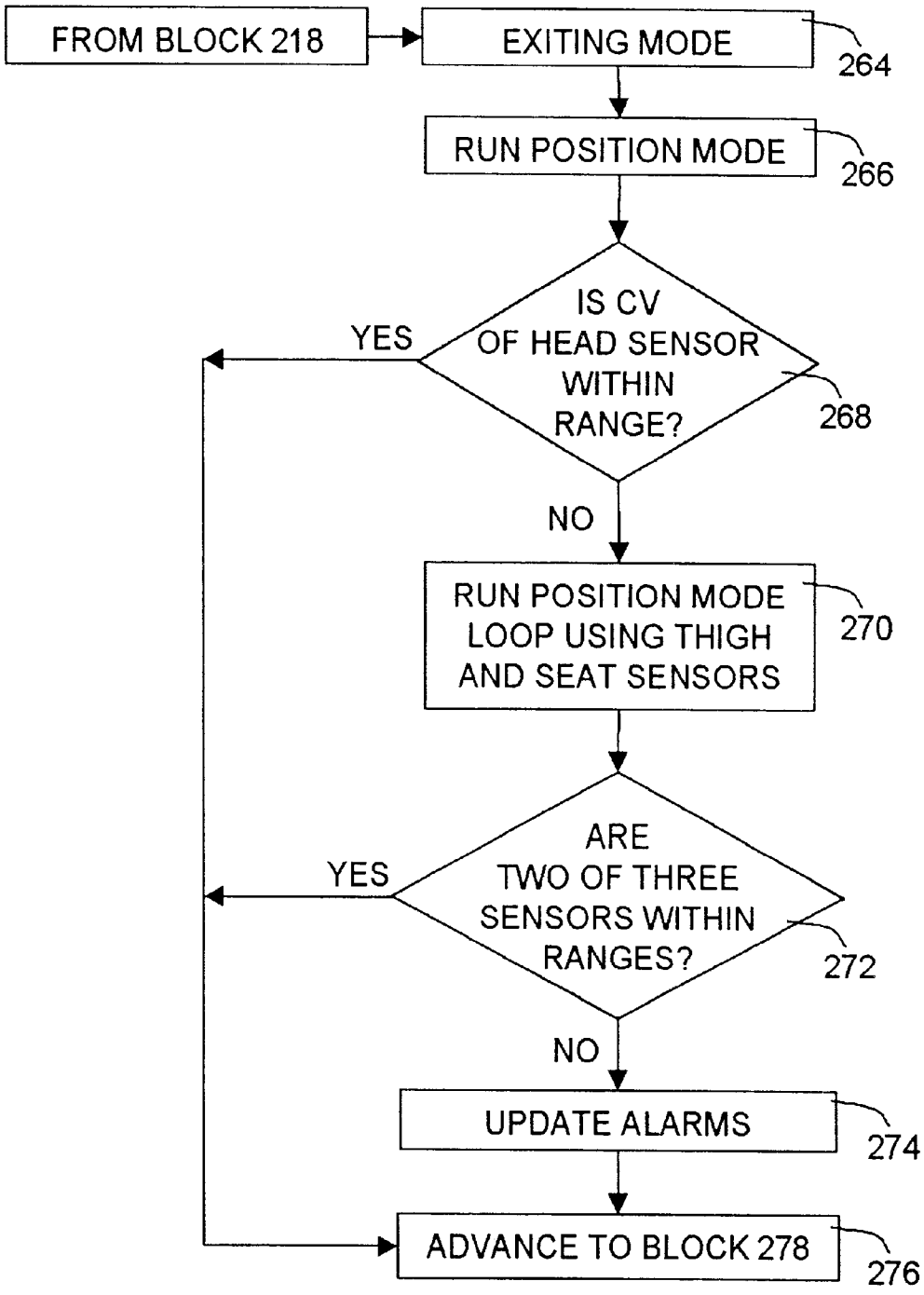

FROM BLOCK 218
EXITING MODE
264
RUN POSITION MODE
266
IS CV OF HEAD SENSOR WITHIN RANGE?
268
YES
NO
RUN POSITION MODE LOOP USING THIGH AND SEAT SENSORS
270
ARE TWO OF THREE SENSORS WITHIN RANGES?
272
YES
NO
UPDATE ALARMS
274
ADVANCE TO BLOCK 278
276

FIG. 12

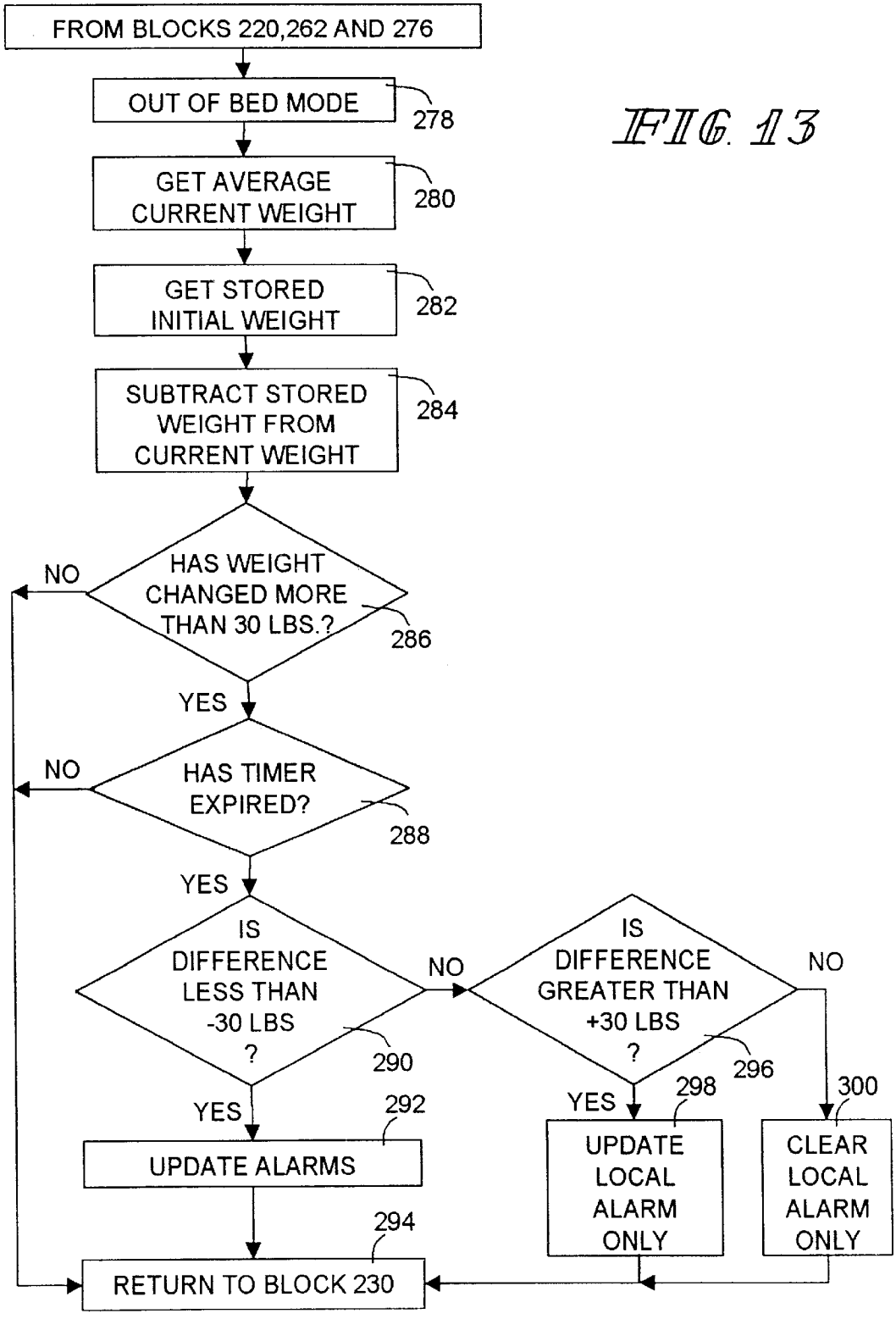
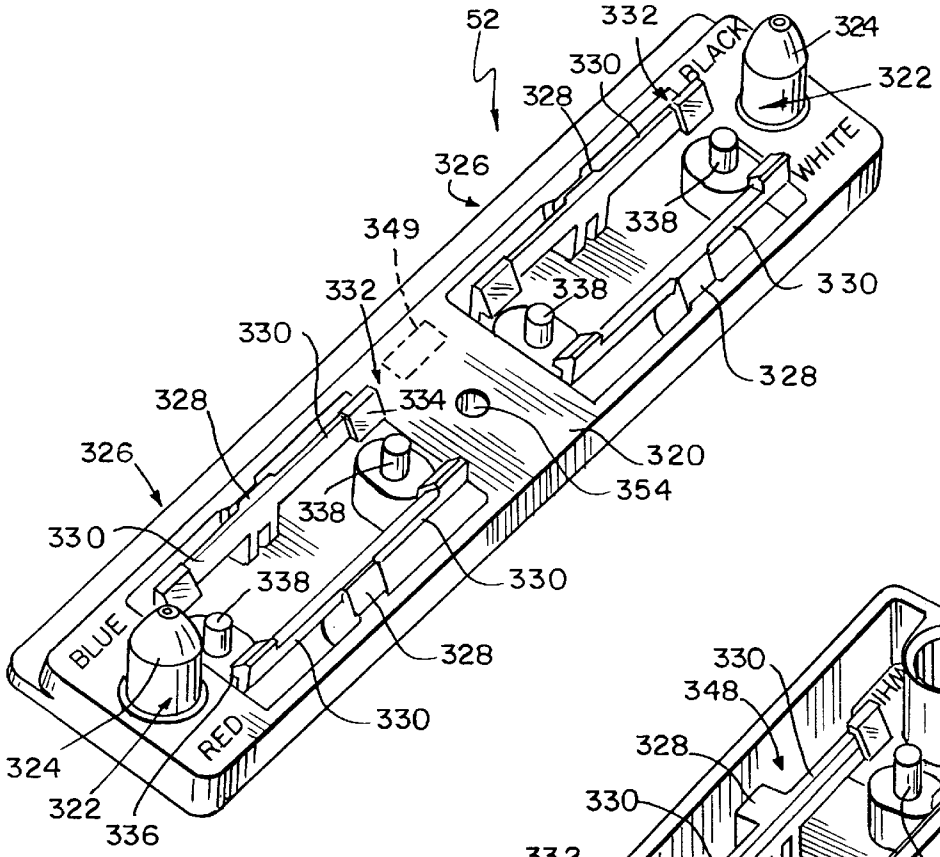

FROM BLOCKS 220,262 AND 276
OUT OF BED MODE
278
GET AVERAGE CURRENT WEIGHT
280
GET STORED INITIAL WEIGHT
282
SUBTRACT STORED WEIGHT FROM CURRENT WEIGHT
284
HAS WEIGHT CHANGED MORE THAN 30 LBS.?
286
NO
YES
HAS TIMER EXPIRED?
288
NO
YES
IS DIFFERENCE LESS THAN -30 LBS ?
290
NO
IS DIFFERENCE GREATER THAN +30 LBS ?
296
NO
YES
298
300
YES
292
UPDATE ALARMS
UPDATE LOCAL ALARM ONLY
CLEAR LOCAL ALARM ONLY
294
RETURN TO BLOCK 230

FIG. 13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332
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330
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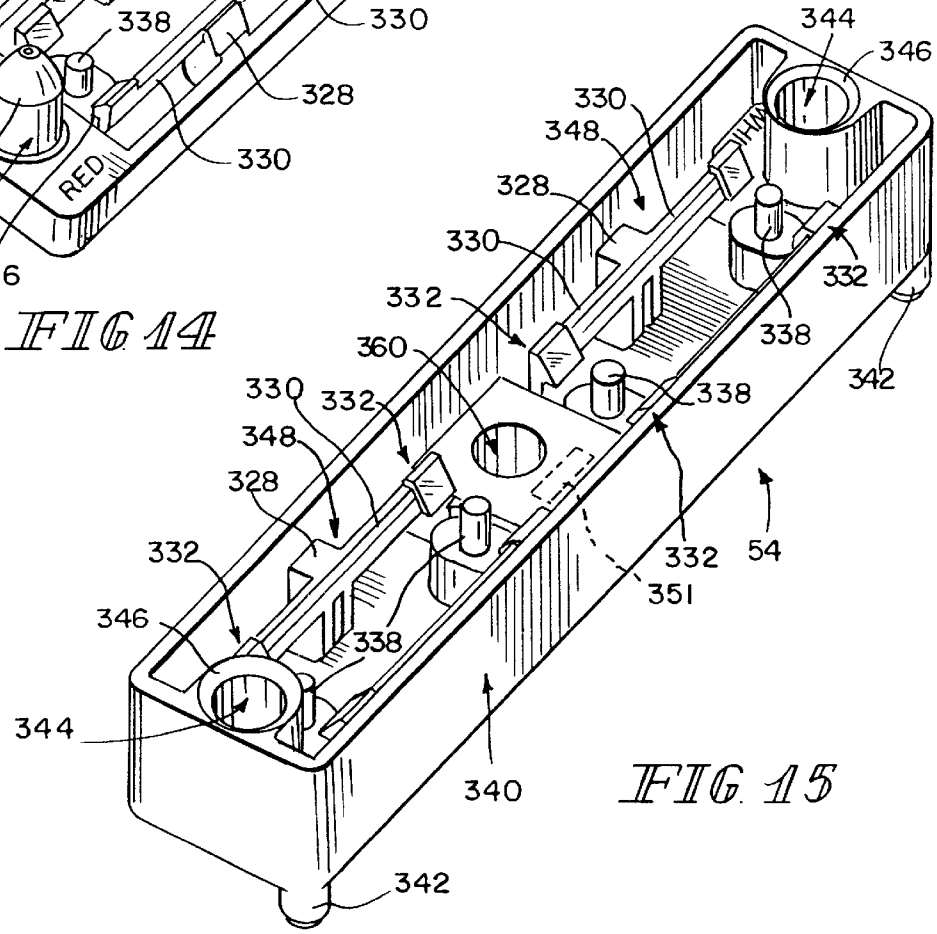
338
328
BLUE
330
RED
324
322
336

FIG 14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346
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348
WHITE
328
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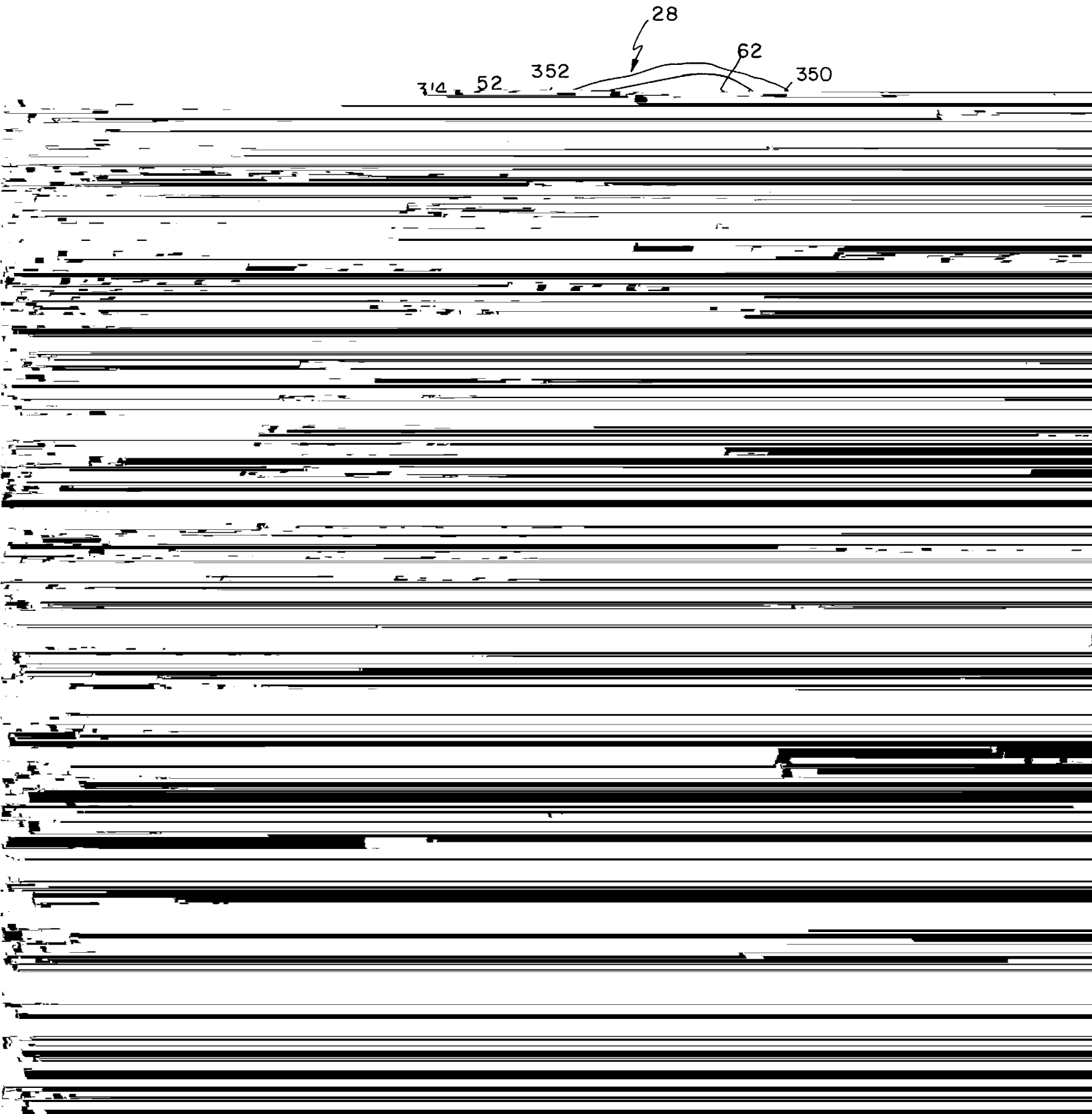
344
340
342

FIG 15


28
62
352
350
314
52

PATIENT POSITION DETECTION APPARATUS FOR A BED

This application is a continuation of U.S. patent application Ser. No. 09/737,111, filed Dec. 14, 2000, now U.S. Pat. No. 6,320,510, which is a divisional of U.S. patent application Ser. No. 09/264,174, filed Mar. 5, 1999, now U.S. Pat. No. 6,208,250, the disclosures of which are incorporated herein by reference.

BACKGROUND SUMMARY OF THE INVENTION

The present invention relates to a patient position detection apparatus for a bed. More particularly, the present invention relates to a bed exit and patient position detection apparatus which has multiple modes of operation for providing information to a caregiver regarding a location of a

FIG. **4** is a partial sectional view illustrating a load cell configured to connect the weigh frame to the base frame;

FIG. **5** is a perspective view of a head end siderail which includes a control panel for operating the patient position detection apparatus of the present invention;

FIG. **6** is an enlarged view of the control panel of FIG. **5** which is used to control the mode of operation of the patient position detection apparatus and the volume of the alarms generated by the detection apparatus;

FIG. **7** is a block diagram illustrating the control electronics of the patient position detection apparatus;

FIG. **8** is a top plan view of the articulating deck of the bed with the second set of sensors mounted on the deck;

FIGS. **9** and **10** are flow charts illustrating a main loop of steps performed by the controller for monitoring inputs from the control panel and the first and second sets of sensors to

position (not shown) located above a top surface **36** of mattress **38**. Mattress **38** is located on articulating deck **22** for supporting a patient thereon.

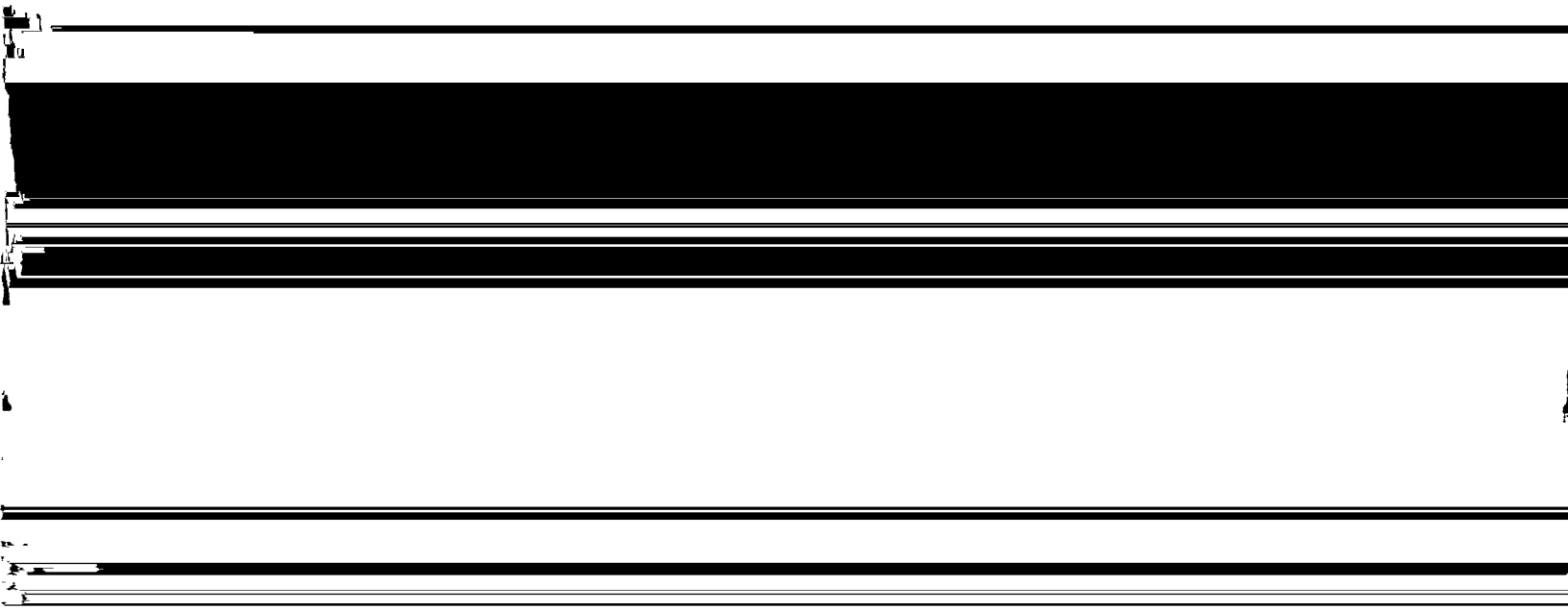
The footboard **28** includes a plurality of buttons, knobs, switches or other controls **40** for controlling various functions of the bed **10**. Controls **40** are located on a top inclined panel **42** and a bottom inclined panel **44** on the footboard **28**.

therefore provide initial alignment between the footboard **28** and the frame **20**. First and second connector alignment apparatuses **52** and **54** provide further alignment for male and female electrical connectors **62** and **64**, respectively, as discussed in detail below with reference to FIGS. **14–16**.

The patient position detection apparatus of the present invention uses two different types of sensors **70**, **104**. A first

resistive pressure sensors are formed in strips which can be cut to any desired length. The sensor strips are illustratively adhered to a stiffener and then sealed within a protective outer sleeve or cover made from a wipable material. Fasteners **116** are illustratively rivets which secure the sensors

the nurse call **142** alarm once the nurse call **142** alarm has been activated at the remote nurse call station. Nurse call clear button **144** permits the caregiver to clear or reset the remote patient alarm while at the bed **10** after responding to the alarm condition. Currently, caregivers must cancel the



114, **120**, **122**, and **124** in position on the deck **22** as best shown in FIG. **8**. Sensors **114**, **120**, **122**, and **124** are coupled to the controller **50** on the bed **10** by wires **126**.

As pressure on the sensors **114**, **120**, **122**, and **124** increases, resistance of the sensors is lowered. By processing the output signals from sensors **114**, **120**, **122**, and **124**, the controller **50** determines the position of the patient on the deck **22**. In particular, the controller **50** determines when the patient moves away from a central portion of the bed and too close to the side edges **23** or **25** on the deck **22**. Controller **50** then provides an indication that the patient is at risk of exiting the bed.

Using the two different types of sensors **70** and **104**, the patient position detection apparatus of the present invention is capable of operating in several different modes to assist the caregiver with tracking the patient position on the bed **10**. In an out-of-bed mode, only sensors **70** are used to activate an alarm when a patient completely exits the bed. In a second exiting mode, both sets of sensors **70**, **104** are used. An alarm is activated when a patient is located at a position near the sides **23**, **25** of deck **22** or on the deck **22** near the head end **26** or foot end **30**. In other words, a pre-exit alarm is sounded when the patient moves outside a central portion of the deck **22** on the bed **10**. In a third position mode, both sets of sensors **70**, **104** are also used. An alarm is activated when a patient moves away from the head sensor **114** on the deck **22** as discussed below.

FIG. **7** is a block diagram illustrating the electronic control components of the patient position detection apparatus. As discussed above, the first and second sensors **70** and **104** are each coupled to the controller **50**. The controller

nurse call bed exit alarm **142** by returning to the nurse call station or by deactivating the alarm somewhere else in the hospital, other than at the bed **10**. Button **144** permits the caregiver to clear the nurse call bed exit alarm **142** after responding to the alarm condition at the bed **10**. Controller **50** is also coupled to a communication network **55** so that the controller **50** can transmit output signals to a remote location.

In an alternative embodiment of the present invention, controller **50** is programmed to deactivate the local alarm **138** if the patient returns to bed **10** or returns to a correct position on the bed **10** depending upon the mode selected. This feature may encourage the patient to return to the correct position on the bed **10** since the alarm will be deactivated when the patient returns to the correct position. The nurse call alarm **142** typically remains activated so that the caregiver may still respond to the alarm, even if the local audible and visual room alarm **138** is deactivated.

FIG. **6** illustrates further details of the caregiver control panel **130** which is illustratively located on the head end siderail **132**. Control panel **130** includes a key button **150**, a mode control button **152**, and a volume control button **154**. In order to adjust the detection mode or volume of the alarm, the caregiver must depress the key button **150** and hold it down while depressing the desired mode button **152** or volume button **154**. With the key button **150** held down, the caregiver can scroll through the modes of operation by pressing the mode button **152**. Separate indicator LEDs are provided to indicate which mode is selected. The Position Mode is indicated by LED **156**, the Exiting Mode is indicated by LED **158**, and the Out-of-Bed Mode is indicated by

control panel **30** to indicate an alarm condition for that mode. More than one of the LEDs **156**, **158**, and **160** can flash. For instance, in Position Mode, the Position Mode LED **156** may begin to flash when an alarm condition is detected by the Position Mode. Since the Out-of-Bed Mode is also run in Position Mode, the Out-of-Bed LED **160** may also be flashing if the patient has exited the bed.

Caregiver control panel **130** also includes an indicator LED **170** to provide an indication that the bed **10** is not down. This indicator LED **170** is lit when the deck **22** is not in its lowest position relative to the floor. In addition, caregiver panel **130** includes an indicator LED **172** which provides an indication when the brake on the casters **14** is not set. When positioned in a room, the bed **10** is typically set so that the deck **22** is in its lowest position and the brake is set. Therefore, indicator LEDs **170** and **172** provide the caregiver with an indication that these conditions are not met.

FIG. **8** shows the illustrative arrangement of the sensors **114**, **120**, **122**, and **124** on the articulating deck **22**. It is understood that other arrangements of the second set of sensors **104** may be used in accordance with the present invention. In addition, additional sensors may be provided such as a sensor **125** located on the leg deck section **112**. Although the second sensors **104** are illustratively resistive sensors, it is understood that other types of sensors may be used in accordance with the present invention. For example, capacitance sensors such as shown in U.S. Pat. No. 5,808,552 or in U.S. Pat. No. 6,067,019, which are incorporated herein by reference, may be used as the second sensors. In addition, a piezoelectric sensor such as disclosed in U.S. Pat. No. 6,252,512, filed Mar. 5, 1999, entitled A MONITORING SYSTEM AND METHOD, which is hereby incorporated by reference may also be used. In another embodiment, the sensors **104** are coupled to a stop or bottom surface of the mattress **38** or are located within an interior region of the mattress **38**.

FIGS. **9–12** are flow charts illustrating operation of the controller **50** of the present invention and each of the three patient position detection modes. The main software loop of the controller **50** is illustrated in FIGS. **9** and **10**. The main loop begins at block **200** of FIG. **9**. Controller **50** first updates the status of the indicator lights **136** on control panel **130** or elsewhere as illustrated at block **202**. Controller **50** then determines whether the patient detection system is on at block **204**. If the detection system is not on, controller **50** advances to block **230** as illustrated at block **205**. If the patient detection system is on, controller **50** checks the mode of the detection system as illustrated at block **206**. Specifically, controller **50** determines whether the detection system is in position mode as illustrated at block **208**, exiting mode as illustrated at block **210**, or out-of-bed mode as illustrated at block **212**.

If the controller is in position mode as illustrated at block **208** or exiting mode as illustrated at block **210**, the controller **50** will run the control loops for these modes as discussed below. After running the positioning mode loop or the exiting mode loop, the controller **50** will also run the out-of-bed mode loop when the controller is set in position mode or exiting mode. In other words, if the detection system is on, the out-of-bed mode will always be checked.

Controller **50** then determines whether the mode was just activated at block **214**. If the particular mode was not just activated, the controller **50** advances to block **246** of FIG. **11** if the system is in position mode as illustrated at block **216**. If the particular mode was not just activated, controller **50** advances to block **264** of FIG. **12** if the system is in exiting mode as illustrated at block **218**. If the particular mode was not just activated, controller **50** advances to block **278** of FIG. **13** if the system is in out-of-bed mode as illustrated at block **220**.

If the mode was just activated at block **214**, controller **50** reads all the sensor values from the first and second sets of sensors **70** and **104** as illustrated at block **222**. Controller **50** then determines whether the sensor values are within the preset specifications as illustrated at block **224**. In the position mode, controller **50** is only concerned with the head sensor **114**. Therefore, in position mode, the output from head sensor **114** is checked. The output value from sensor **114** is within specification if the head sensor **114** output signal corresponds to a range of weights between 50–450 lbs. Therefore, for position mode, the sensor **114** is typically not within specification if the head sensor **114** is not plugged in, shorted, or if a patient is not on the bed **10**.

For exiting mode, controller **50** checks all the load cells **70** and sensors **114**, **120**, **122**, and **124**. To be within specification for exiting mode, the weight range detected by load cells **70** must be within a predetermined range based on average human weights. Controller **50** also determines whether any of the sensors **114**, **120**, **122**, or **124** are not plugged in or are shorted. In the out-of-bed mode, controller **50** only looks at load cells **70** to make sure that at least a predetermined minimum weight reading is obtained in order to indicate that a patient is on the bed **10**.

If the values read at block **222** are not within specifications, controller **50** will send a local alarm as illustrated at block **226** so that the caregiver can investigate the problem as illustrated at block **226**. Controller **50** then turns the detection system off as illustrated at block **227** and advances to block **230** as illustrated at block **229**. If the retrieved sensor values are within the specifications at block **224**, controller **50** stores all the sensor values in memory **51** as illustrated at block **228**. Controller **50** then advances to block **230** as illustrated at block **229**.

In the illustrated embodiment, the key button **150** on control panel **130** is a hardware switch. If the key button **50** is not pressed, the controller **50** does not receive the signal from the mode button **152** or the volume button **154**. Therefore, if the key button is not pressed as illustrated at block **232**, controller **50** returns to block **200** as illustrated at block **244**. If the key button **150** and the mode button **152** are pressed as illustrated at block **234**, the controller **50** will receive an input based on the mode button press. If the key button **150** and the volume button **154** are pressed as illustrated at block **236**, the controller **50** will receive an input signal from the volume button **154** press. If the key button **150**, the mode button **152**, and the volume button **154** are all pressed as illustrated at block **238**, the controller **50** will receive input signals from both the mode button press and the volume button press. If the key button and at least one other button are pressed at blocks **234**, **236**, and **238**, controller **50** will update the mode and volume settings in memory **51** as illustrated at block **240**. Controller **50** then returns to block **200** as illustrated at block **244**.

Operation of the controller **50** in position mode is illustrated beginning at block **246** of FIG. **11**. Controller **50** first reads the current value of head sensor **114** as illustrated at block **248**. The current head sensor value is abbreviated as CV. Next, controller **50** retrieves the stored value for head sensor **114** which was stored in memory **51** at block **228** as illustrated at block **250**. The stored sensor value is abbreviated as SV. Controller **50** then determines a scaler value

based upon the stored head sensor value. In the illustrated embodiment, an 8 bit A/D converter is used to convert the output from the sensors **104**. Therefore, the value SV ranges from 1–256 in the illustrated embodiment. Smaller values of SV indicate larger weight on the sensors **104**. It is understood that this range could be varied depending upon the particular A/D converter used. Therefore, the range of 1–256 is only for illustrative purposes. Controller **50** sets the scaler value as illustrated in the table at block **252**. The scaler value remains constant until the mode is reactivated. Next, controller **50** calculates the acceptable range for the current head sensor value (CV) as illustrated at block **254**. The acceptable range is:

$$\left(SV - \frac{SV \cdot 10}{\text{SCALER}}\right) < CV < \left(SV + \frac{SV \cdot 10}{\text{SCALER}}\right)$$

Controller **50** determines whether the current head sensor value CV is within the acceptable range as illustrated at block **256**. If so, controller **50** determines that the patient is in the proper position on the deck and returns to block **230** as illustrated at block **262**. If the current head sensor value is not within the acceptable range at block **256**, controller **50** determines whether a timer has expired at block **258**. If not, controller **50** advances back to block **230**. If the timer has expired, controller **50** determines that the patient is out of position and activates the local alarms **138** as illustrated at block **260**. Controller **50** also activates a nurse call alarm **142**, and may turn on the room lights **140** at block **260**. Controller **50** then advances to block **278** and runs the out-of-bed mode check as illustrated at block **262**.

Operation of the patient detection system in exiting mode is illustrated beginning at block **264** in FIG. **12**. Controller **50** advances to block **264** from block **218** in FIG. **9**. In exiting mode, controller **50** first runs the positioning mode loop as illustrated at block **266**. In other words, the controller **50** uses head sensor **114** to check the patient's position using the flow chart discussed above in reference to FIG. **11**. Controller **50** determines whether the current head sensor value CV is within the acceptable range as illustrated at block **268**. If so, controller **50** determines that the patient is in the proper position and advances to block **278** to run the out-of-bed mode check as illustrated at block **276** in FIG. **12**.

If the head sensor value is not within the acceptable range at block **268**, controller **50** runs a sensor test for seat sensor **120** and thigh sensors **122** and **124** using a similar test as in FIG. **11**. Scaler values may be adjusted for the different sensors **120**, **122**, and **124**, if necessary. Scaler values are selected by applying a known load above a particular sensor location and taking an output reading. Next, a predetermined distance from the sensor is selected at which point it is desired to activate the alarm. The known weight is than moved to that desired alarm location and another output reading is taken. The scaler value is calculated the percentage change between the output of the sensor when the known weight applied directly over the sensor and the

block **272**, controller **50** determines that the patient is out of position and updates the local alarms **238**, activates the nurse call alarm **142**, and may turn on the room lights **140** as illustrated at block **274**. Controller **50** then advances to block **230** as illustrated at block **276**. In exiting mode, the patient position detection apparatus of the present invention permits the patient to move around more on the deck **22** before an alarm is activated compared to the position mode. Therefore, position mode is the most sensitive setting for the patient position detection apparatus of the present invention.

It is understood that other configurations may be provided for the locations of sensors **104**. A different number of sensors **104** may be used. The sensors **104** may be mounted at different locations on the deck **22**, on the mattress **38**, or elsewhere on the bed **10**.

Operation of the patient position detection system in the out-of-bed mode is illustrated beginning at block **278** in FIG. **13**. Controller **50** advances to block **278** from block **220** in FIG. **9**. In the out-of-bed mode, controller **50** detects an average current weight of the patient as illustrated at block **280**. For instance, the controller **50** can take four readings from each load cell **70** and divide by four to get an average current weight. Next, controller **50** retrieves the stored initial weight from memory **51** as illustrated at block **282**. Controller **50** subtracts the stored weight from the current weight as illustrated at block **284**.

Next, controller **286** determines whether the weight on the bed **10** detected at block **280** has increased or decreased by more than 30 lbs. compared to the initial stored weight retrieved at block **282**. If the weight has not changed by more than 30 lbs., controller returns to block **230** as illustrated at block **294**. If the weight has changed by more than 30 lbs. at block **286**, controller **50** determines whether a timer has expired at block **288**. If the timer has not expired, controller **250** advances to block **230** as illustrated at block **294**. If the timer has expired at block **288**, the controller **50** determines whether the difference calculated at block **284** is less than −30 lbs. at block **290**. If so, controller **50** determines that the patient has exited the bed **10** and updates the local alarms **138**, the nurse call alarm **142** and may turn on the room lights **140** as illustrated at block **292**. Controller **50** then returns to block **230** as illustrated at block **294**.

If the difference is not less than −30 lbs. at block **290**, controller **50** determines whether the difference calculated at block **284** is greater than 30 lbs. as illustrated at block **296**. If so, controller **50** determines that substantial additional weight has been added to the bed and updates local alarms **138** only as illustrated at block **298**. The nurse call alarm **142** may also be activated, if desired. Controller **50** then advances to block **230** as illustrated at block **294**. If the difference is not greater than 30 lbs. at block **296**, controller **50** clears the local alarm only at block **300** and then advances to block **230** as illustrated at block **294**.

It is understood that the 30 lbs. threshold value for the out-of-bed mode may be adjusted upwardly or downwardly depending upon the weight of the patient. In other words, if

in order to arm the bed exit detector. In the out-of-bed mode of the present invention, removing the patient from the bed is not required in order to arm the bed exit detection system.

The patient position detection system of the present invention may be quickly switched from a normal bed exit system in which an alarm is generated only when a patient exits the bed to a predictive bed exit system in which an alarm is generated when a patient moves away from a center portion of the bed. In an embodiment of the invention, the output signals from the first and second set of sensors **70**, **104** are monitored and stored, either at the bed **10**, or at a remote location to record movements of the patient. The controller **50** or a controller at the remote location monitors the sensor output values to determine whether the patient is moving on the bed **10**. In one embodiment, the controller **50** or controller at a remote location generates a caregiver alert signal or alarm if the patient has not moved on the bed within a predetermined period of time. Therefore, the caregiver can go to the bed **10** and rotate the patient in order to reduce the likelihood that the patient will get bed sores. For example, if the patient hasn't moved for a predetermined period of time, such as two hours, a signal is generated advising the caregiver to move the patient. If the sensors **70**, **104** and controller detect that the patient has moved within the predetermined period, then there is no need for the caregiver to go turn the patient. Therefore, no signal is generated. This feature saves caregiver time and reduces the likelihood of injuries due to unnecessary rotation of a patient who has been moving.

In another embodiment of the present invention, the output signals from the four sensors **70** located at the corners of the base frame **12** are used to provide an indication when one of the frames or the deck hits an obstruction when moving from the high position to a low position. In particular, the processor **50** determines when an output signal from one of the sensors **70** at the corners generates a negative value or a greatly reduced weight reading within a

than terminals **312**. The terminals **312** are electrically connected to conductors of a cable **314**. Cable **314** of connectors **62** are connected to controls **40**. Connector alignment apparatus **54** is configured to receive female electrical connectors **64**. Those numbers referenced by numbers on connectors **62** perform the same or similar function. Connectors **64** include female socket contacts **318** configured to receive terminals **312** of connector **302**. Illustratively, cables extending from connectors **64** are coupled to the controller **50** on bed **10**.

Referring now to FIG. **14**, connector alignment apparatus **52** includes a base plate **320** having outwardly extending alignment posts **322** located at opposite ends. Posts **322** each include tapered head portions **324**. Alignment apparatus **52** includes a pair of connector receiving portions **326**. Connector receiving portions **326** each include a pair of center posts **328**. Each post **328** includes a pair of spring arms **330**. Each spring arm **330** has a head portion **332** including a ramp surface **334** and a bottom lip **336**. Each connector receiving portion **326** also includes a pair of posts **338**.

Electrical connectors **62** are installed into the connector receiving portions **326** by locating the apertures **310** on flanges **308** over the posts **338** and pushing the connector **62** toward base **320**. Flanges **306** engage ramp surfaces **334** of heads **332** and cause the spring arms **330** to be deflected. Once the flanges **306** move past the heads **332**, heads **332** then move over flanges **306** to retain the connectors **302** within the connector alignment apparatus **52** as best shown in FIG. **16**.

Second connector alignment apparatus **54** is best illustrated in FIG. **15**. The alignment apparatus includes a body portion **340** having a pair of downwardly extending alignment posts **342**. Body portion **340** is formed to include apertures **344** at opposite ends. Apertures **344** are configured to receive the posts **322** of first connector alignment apparatus **52** as discussed below. Lead-in ramp surfaces **346** are formed around the apertures **344**. Body portion **340** further

within apertures **362** formed in the surface **356** of the frame **20**. Housing **340** is therefore not rigidly coupled to frame **20** and can float slightly due to the oversized apertures **362** and the oversized aperture **360**.

During installation of the footboard **28** on to the frame **20**, initial alignment is provided by posts **58** on frame **20** extending into the apertures **56** formed in the footboard **28**. As the footboard **28** moves downwardly over the posts **58**, the posts **322** on first connector alignment apparatus **52** enter the apertures **344** in the second connector alignment apparatus **54**. Tapered surfaces **324** on posts **22** and tapered surfaces **346** of apertures **344** facilitate insertion of the posts **322** into the apertures **344**. Since the housing **340** of second connector alignment apparatus **54** can float on the frame **20**, the housing **340** moves into proper alignment with the first connector alignment apparatus **52** as the footboard **28** is installed. This ensures proper alignment between connectors **62** and **64**. Typically, connectors **62** and **64** include further alignment posts **313** and apertures **315**, respectively, which mate to make sure that each of the terminals **312** line up with the socket contacts **318**. Therefore, the connector alignment apparatus of the present invention includes a combination of posts **58** on the frame **20** which mate with aperture **56** on the footboard **28**, posts **322** on the first connector alignment apparatus **52** which mate with apertures **344** on the second connector alignment apparatus **54**, and posts **313** on connectors **62** which mate with apertures **315** on the connectors **64** to provide further alignment.

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

What is claimed is:

1. An apparatus for supporting a patient, the apparatus comprising:

a frame,

a mattress supported by the frame, and

a patient position detection system including an alarm and at least one sensor, the patient position detection system being configured to detect a position of the patient relative to the mattress, the patient position detection system having at least first, second, and third alarm modes of operation, the patient position detection system being configured to provide for selection of one of the first, second, and third modes as a selected mode, the first mode of operation resulting in an alarm being activated in the event the first mode is the selected mode and the patient moves by a first amount, the second mode of operation resulting in the alarm being activated in the event the second mode is the selected mode and the patient moves by a second amount greater than the first amount, and the third mode of operation resulting in the alarm hem activated in the event the third mode is the selected mode and the patient moves a third amount greater than the second amount.

2. The apparatus of claim **1**, wherein the third mode of operation results in the alarm being activated in the event the patient exits the mattress.

3. The apparatus of claim **1**, wherein the patient position detection system includes at least one first sensor coupled to the frame, the at least one first sensor having an output signal witch is variable in response to changes in a weight applied to the mattress, at least one second sensor located adjacent the mattress, the at least one second sensor having an output signal which is variable in response to changes in the position of the patient on the mattress, and a controller having inputs configured to receive the output signals from the first and second sensors, the controller being configured to monitor the output signals, to provide an indication of changes in the position of the patient relative to the mattress, and to activate the alarm.

4. The apparatus of claim **3**, wherein the at least one first sensor is a load cell and the at least one second sensor is one of a resistive pressure sensor, a capacitance sensor, and a piezoelectric sensor.

5. The apparatus of claim **1**, further comprising a deck coupled to the frame, the mattress being located on the deck, the deck including a head deck section, a seat deck section, a thigh deck section, and a leg deck section, and wherein at least one head sensor is coupled to the head deck section, at least one seat sensor is coupled to the seat deck section, and at least one thigh sensor is coupled to the thigh deck section.

6. The apparatus of claim **1**, wherein the patient position detection system includes a controller coupled to the at least one sensor and first, second, and third mode indicator lights which correspond to first, second, and third modes of operation of the patient position detection system, respectively, the controller being coupled to the first, second, and third mode indicator lights to indicate which mode has been selected.

7. The apparatus of claim **1**, wherein the patient position detection system includes a controller coupled to the at least one sensor and further comprising a control panel coupled to the controller to permit a caregiver to select between the first, second and third modes of operation.

8. The apparatus of claim **7**, wherein the control panel includes an actuator to permit the caregiver to adjust a volume of the alarm.

9. The apparatus of claim **7**, wherein the control panel includes a key button and a separate mode button, the controller permitting the caregiver to change the mode of operation by pressing the mode button only in the event the key button is also pressed.

10. The apparatus of claim **7**, wherein the control panel includes a key button and a separate a volume control button to permit the caregiver to adjust a volume of the alarm, the controller being configured to permit the caregiver to adjust the volume of the alarm using the volume control button only in the event the key button is also pressed.

11. The apparatus of claim **1**, wherein the patient position detection system is coupled to a communication port to provide a nurse call alarm to a remote location when the alarm is activated.

12. The apparatus of claim **1**, wherein the first mode of operation results in the alarm being activated in the event the patient moves away from a central region of the mattress by a first distance, the second mode of operation results in the alarm being activated in the event the patient moves away from the central region of the mattress by a second distance greater than the first distance, and the third mode of operation results in the alarm being activated in the event the patient exits the mattress.

13. The apparatus of claim **1**, wherein the patient position detection system is configured to activate the alarm in the event the system is in one of the modes and a patient approaches exiting the mattress.

14. The apparatus of claim **1**, wherein the patient position detection system further includes a single mode selector configured to permit scrolling selection of the first, second, and third modes.

15. The apparatus of claim **1**, wherein the patient position detection system includes a plurality of sensors and a

controller that receives signals from the plurality of sensors and determines whether to activate the alarm based on the signals and the selected mode.

16. The apparatus of claim **15**, wherein each of the plurality of sensors has an electrical resistance that varies with the position of a patient on the mattress.

17. The apparatus of claim **15**, further comprising a deck positioned over the frame, wherein the mattress is positioned on the deck and the plurality of sensors includes a plurality of load cells supporting the weight of the deck and mattress.

18. The apparatus of claim **1**, further comprising a footboard positioned on a foot end of the apparatus and a display coupled to the footboard wherein the patient position detection system includes a plurality of sensors, the display is configured to indicate the weight of a patient positioned on the mattress based on signals generated by the plurality of sensors.

19. The apparatus of claim **1**, wherein the patient position sensor further includes a digital controller and an A/D converter configured to convert an analog signal from the at least one sensor to a digital signal.

20. An apparatus for supporting a patient, the apparatus comprising:

a frame,

a mattress supported by the frame, and

a patient position detection system including an alarm and the patient position detector having first, second, and third modes of operation, the first, second, and third modes being selectable to permit adjustment of a sensitivity of the patient position detection system, in the event the first mode is selected, the alarm is activated in response to the patient moving a first distance, in the event the second mode is selected, the alarm is activated in response to the patient moving a second distance greater than the first distance, and in the event the third mode is selected, the alarm is activated in response to the patient moving a third distance greater than the second distance.

21. The apparatus of claim **20**, wherein the third mode of operation results in the alarm being activated in the event the patient exits the mattress.

22. The apparatus of claim **20**, wherein the patient position detector includes a plurality of sensors configured to generate an output signal which is variable in response to changes in a weight applied to the mattress and an output signal which is variable in response to changes in the position of the patient on the mattress, and patient position detector further includes a controller configured to receive the output signals from the plurality of sensors, the controller being configured to monitor the output signals, to provide an indication of changes in the position of the patient relative to the mattress, and to activate the alarm.

23. The apparatus of claim **20**, wherein the the first mode of operation results in the alarm being activated in the event the patient moves away from a central region of the mattress by the first distance, the second mode of operation results in the alarm being activated in the event the patient moves away from the central region of the mattress by the second distance, the third mode of operation results in the alarm being activated in the event the patient exits the mattress.

24. The apparatus of claim **20**, further comprising a deck coupled to the frame, the mattress being located on the deck, the deck including a head deck section, a seat deck section, a thigh deck section, and a leg deck section, and wherein the patient position detector includes at least one head sensor coupled to the head deck section, at least one seat sensor coupled to the seat deck section, and at least one thigh sensor coupled to the thigh deck section.

25. The apparatus of claim **20**, further comprising first, second, and third mode indicator lights which correspond to the first, second, and third modes of operation of the patient position detector, respectively, the patient position detector being coupled to the first, second, and third mode indicator lights to indicate which mode has been selected.

26. The apparatus of claim **20**, further comprising a control panel coupled to the patient position detector to permit a caregiver to select between the first, second and third modes of operation.

27. The apparatus of claim **26**, wherein the control panel includes a key button and a separate mode button, the patient position detector being configured to permit the caregiver to change the mode of operation by pressing the mode button only in the event the key button is also pressed.

28. The apparatus of claim **20**, wherein the patient position detection system is configured to activate the alarm in the event the system is in one of the modes and a patient approaches exiting the mattress.

29. The apparatus of claim **20**, wherein the patient position detection system further includes a single mode selector configured to permit scrolling selection of the first, second, and third modes.

30. The apparatus of claim **20**, wherein the patient position detection system includes a plurality of sensors and a controller that receives signals from the plurality of sensors and determines whether to activate the alarm based on the signals and the selected mode.

31. The apparatus of claim **30**, wherein each of the plurality of sensors has an electrical resistance that varies with the position of a patient on the mattress.

32. The apparatus of claim **30**, further comprising a deck positioned over the frame, wherein the mattress is positioned on the deck and the plurality of sensors includes a plurality of load cells supporting the weight of the deck and mattress.

33. The apparatus of claim **20**, further comprising a footboard positioned on a foot end of the apparatus and a display coupled to the footboard, wherein the patient position detection system includes a plurality of sensors, the display is configured to indicate the weight of a patient positioned on the mattress based on signals generated by the plurality of sensors.

34. The apparatus of claim **20**, wherein the patient position sensor further includes a digital controller and an A/D converter configured to convert an analog signal from the at least one sensor to a digital signal.

35. A patient support comprising:

a frame,

a mattress supported by the frame, and

a patient position detection system including a controller, an alarm, and a plurality of sensors, the controller being configured to receive data from the plurality of sensors indicative of the position of the patient relative to the mattress, the patient position detection system having a first mode of operation in which the controller activates the alarm to indicate that the patient is in a first position relative to the mattress, the patient position detection system having a second mode of operation in which the controller activates the alarm to indicate that the patient is in a second position relative to the mattress, the patient position detection system having a third mode of operation in which the controller activates the alarm to indicate that the patient is in a third position relative to the mattress, the data received by the controller from the plurality of sensors also being used by the controller to determine a weight of the patient resting on the mattress.

36. The patient support of claim 35, further comprising a display configured to display the weight of the patient.

37. The patient support of claim 36, further comprising a footboard positioned adjacent a foot end of the patient support, wherein the display is supported by the footboard.

38. The patient support of claim 37, wherein the footboard is removable from the frame, the frame includes a first electrical connector, the footboard includes a second electrical connector that couples with the first electrical connector when the footboard is coupled to the frame to provide electrical communication to the display, and the second electrical connector is spaced apart from the first electrical connector when the footboard is removed from the frame.

39. The patient support of claim 35, further comprising a barrier positioned adjacent a perimeter of the mattress, the barrier including a selector in communication with the controller, the selector being configured to permit a user to select one of the first, second, and third modes as a selected mode.

40. The apparatus of claim 39, wherein the selector is configured to permit scrolling selection of the first, second, and third modes.

41. The patient support of claim 35, wherein the plurality of sensors includes a plurality of load cells in communication with the controller to determine the weight and position of the patient.

42. The patient support of claim 41, further comprising a deck supporting the mattress, wherein the plurality of load cells support the weight of the deck and the mattress.

43. A patient support comprising:

a frame,

a deck positioned above the frame,

a mattress positioned above the deck, and

a patient position detection system including a controller, an alarm, and a plurality of sensors, the controller being configured to receive data from the plurality of sensors indicative of the position of the patient relative to the mattress, the patient position detection system having a first mode of operation in which the controller activates the alarm to indicate that the patient has moved a first distance from a location on the mattress, the patient position detection system having a second mode of operation in which the controller activates the alarm to indicate that the patient has moved a second distance from the location on the mattress, the patient position detection system having a third mode of operation in which the controller activates the alarm to indicate the patient has moved a third distance from the location on the mattress, the second distance being greater than the first distance, the third distance being greater than the second distance, the patient position detection system being configured to permit selection of the mode of operation to permit adjustment of a sensitivity of the system before the alarm is activated, the plurality of sensors including a plurality of load cells supporting the weight of the deck and providing data to the controller to determine the position of the patient and a weight of the patient resting on the mattress.

44. The patient support of claim 43, further comprising a footboard positioned adjacent a foot end of the patient support and a display supported by the footboard.

45. The patient support of claim 44, wherein the footboard is removable from the frame, the frame includes a first electrical connector, the footboard includes a second electrical connector that couples with the first electrical connector when the footboard is coupled to the frame to provide electrical communication to the display, and the second electrical connector is spaced apart from the first electrical connector when the footboard is removed from the frame.

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