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(54) **PATIENT MONITORING SYSTEM**

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(57) **ABSTRACT**

To monitor a patient, an alligator clip is fastened to the patient by a cord having a length of between five inches and five feet. The other end of the cord is connected to a switch which is activated when the patient moves beyond the length of the cord to cause a message to be announced. A disposable pressure pad is located under the patient and armed by the application of weight to the pad. Upon removal of the weight the alarm is given.

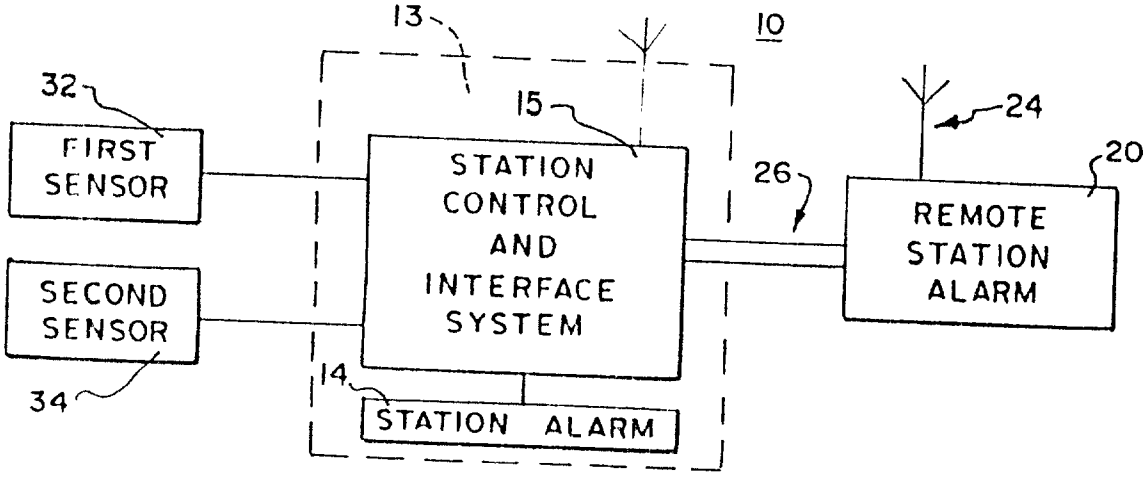


FIG. 1

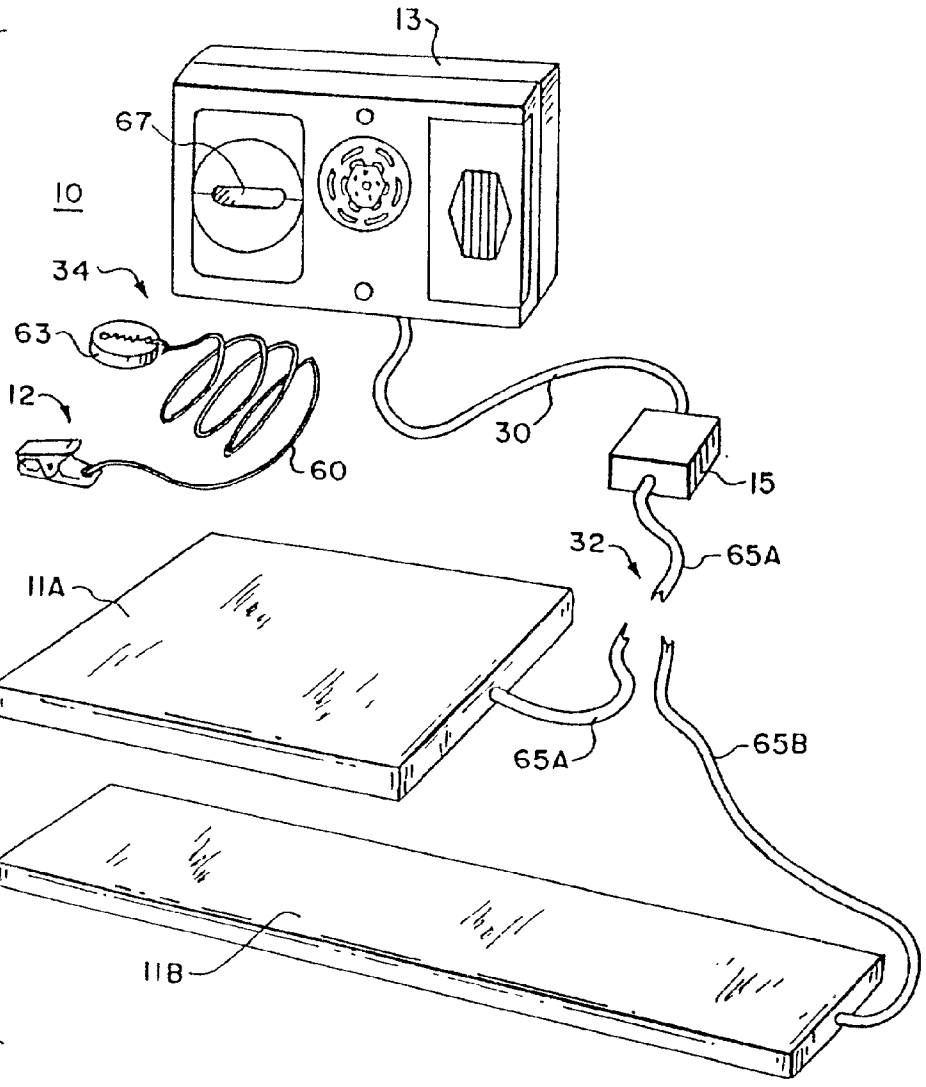

13
67
10
34
63
12
60
30
15
32
65A
11A
65A
65B
11B

FIG. 2

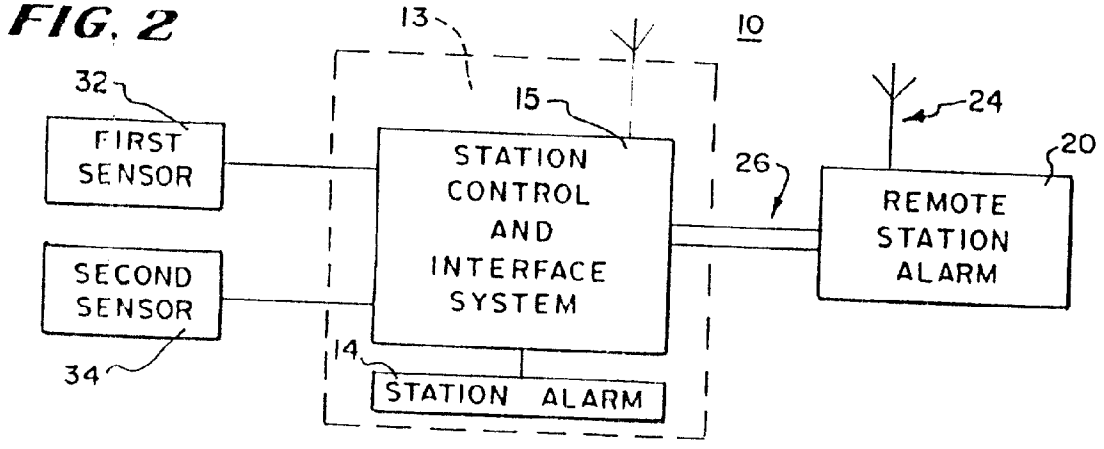

13
10
32
15
24
20
26
FIRST SENSOR
SECOND SENSOR
STATION CONTROL AND INTERFACE SYSTEM
REMOTE STATION ALARM
34
14
STATION ALARM

FIG. 3

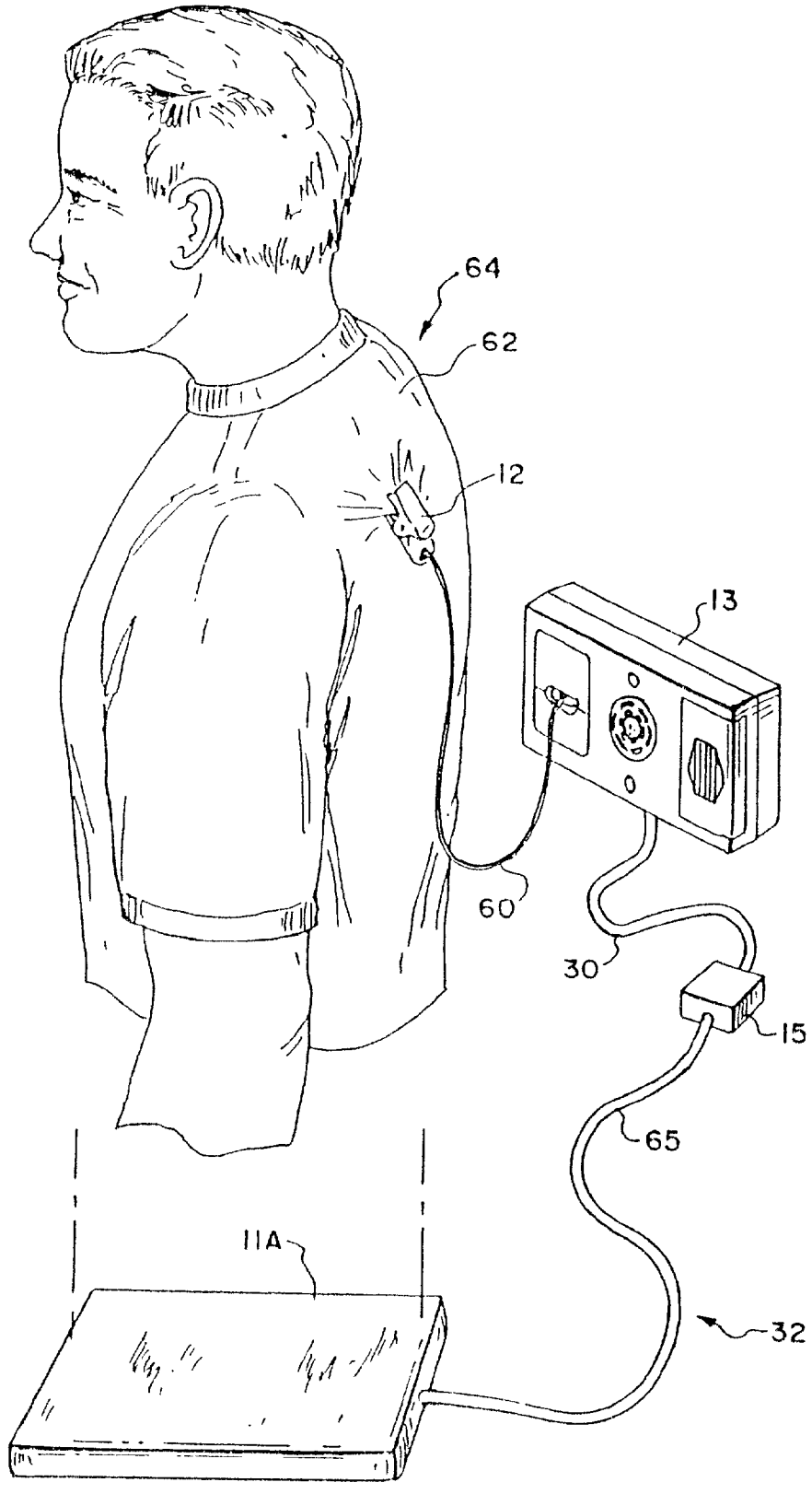
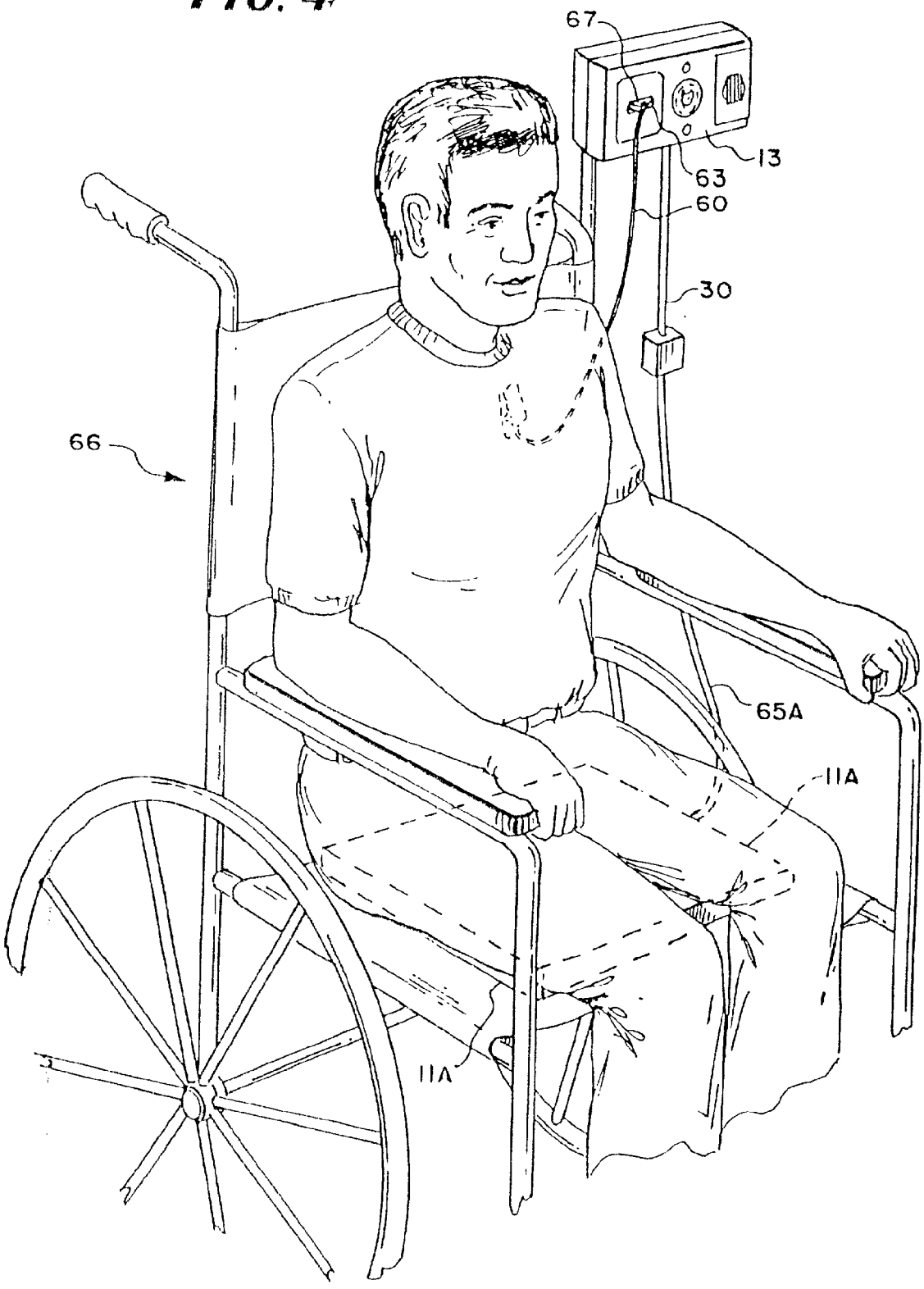


FIG. 4



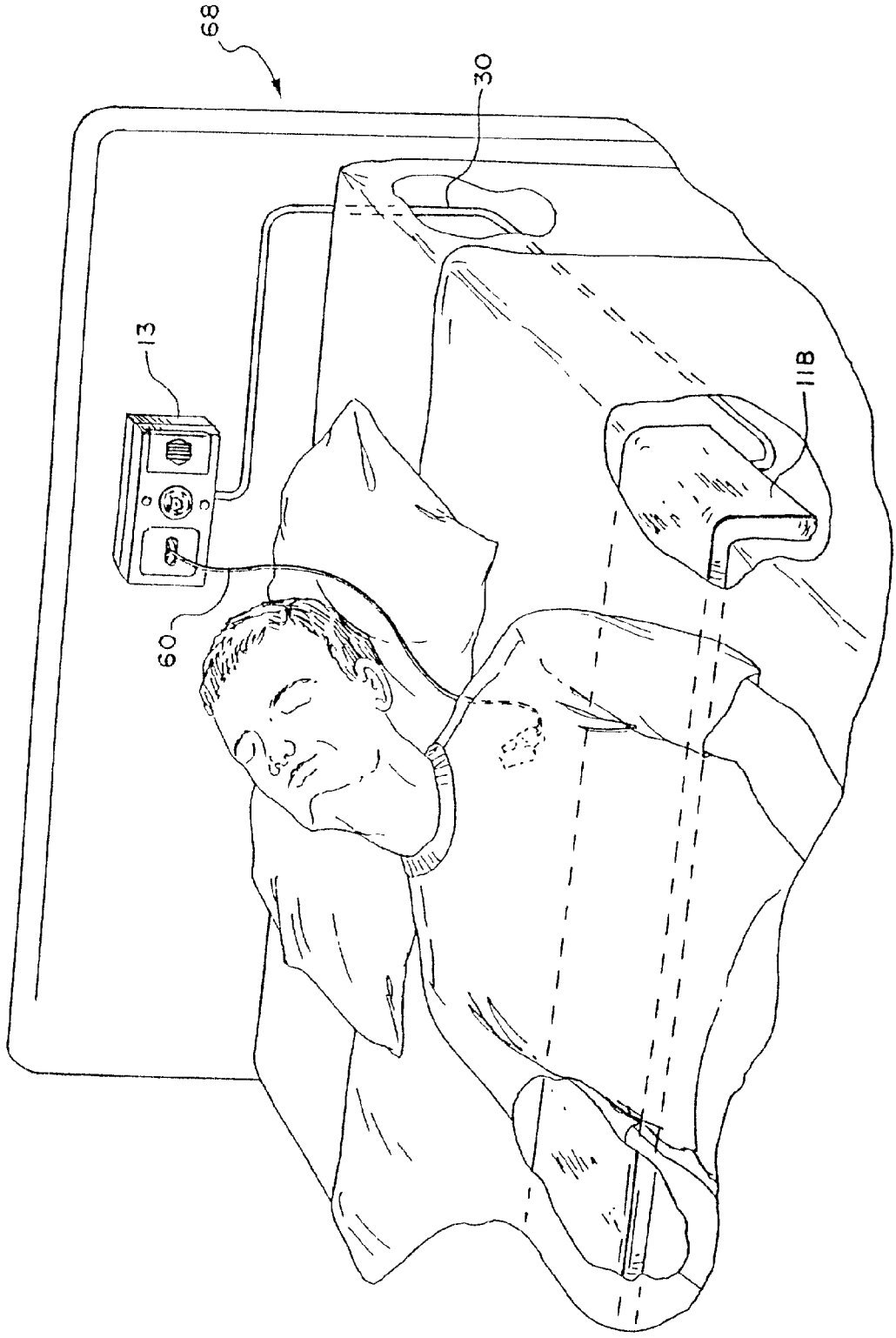


FIG. 5

FIG. 6

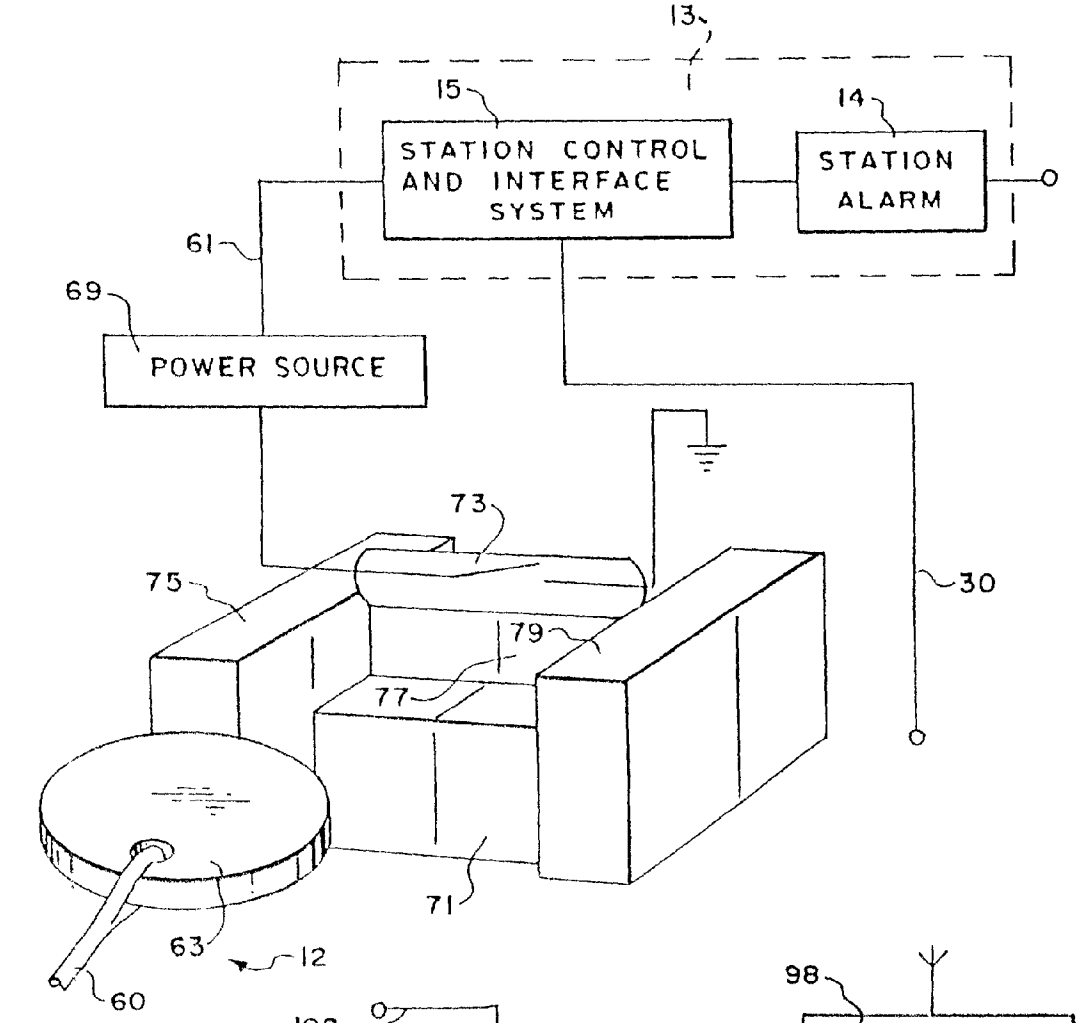

13
15
STATION CONTROL AND INTERFACE SYSTEM
14
STATION ALARM
61
69
POWER SOURCE
73
75
30
79
77
71
63
12
60

FIG. 7

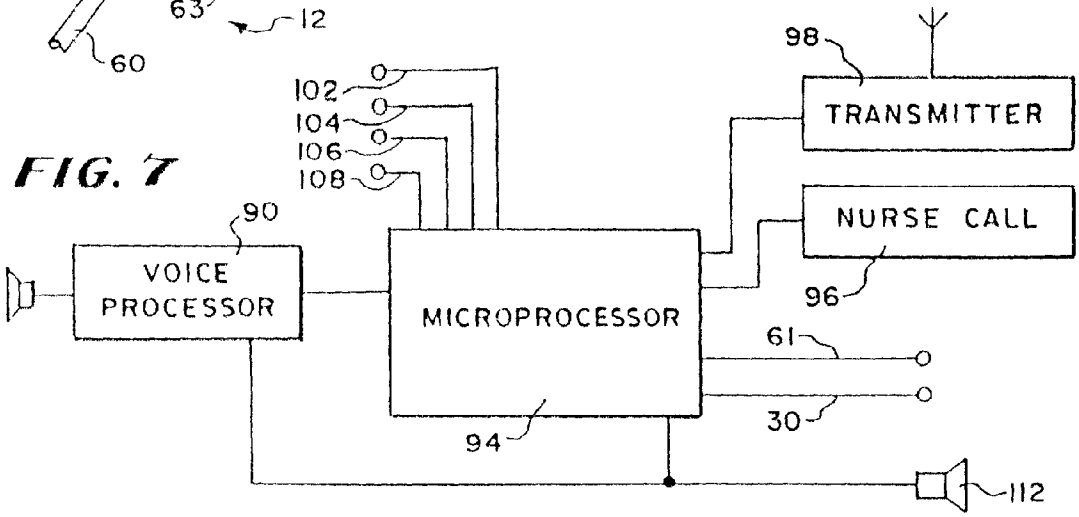

98
TRANSMITTER
102
104
106
108
NURSE CALL
90
VOICE PROCESSOR
MICROPROCESSOR
96
61
30
94
112

FIG. 8

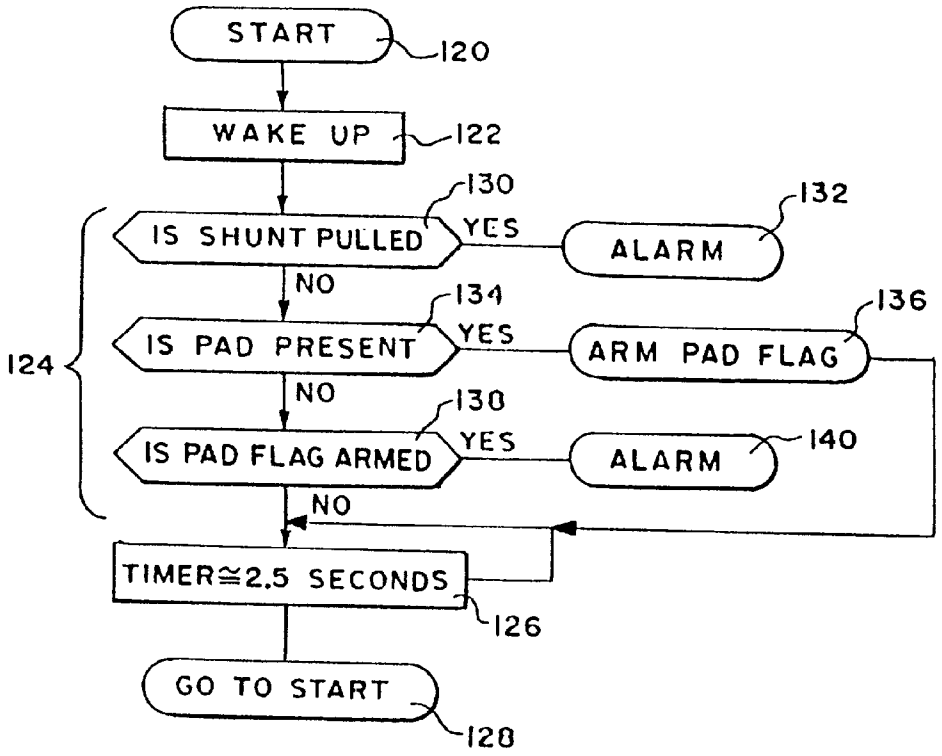
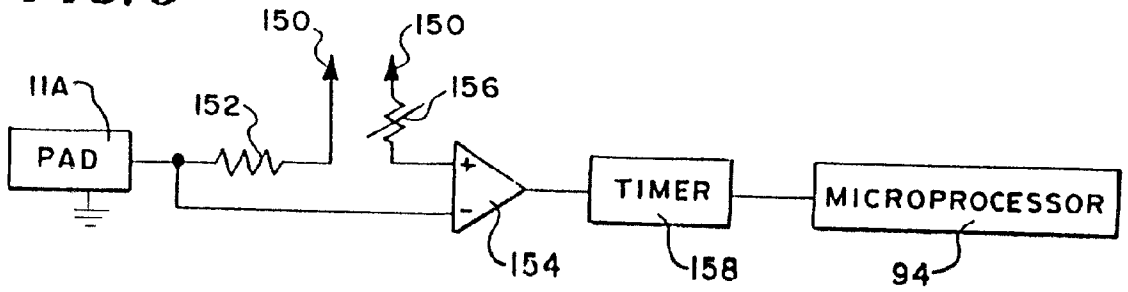

START
120
WAKE UP
122
130
IS SHUNT PULLED
YES
132
ALARM
NO
134
IS PAD PRESENT
YES
136
ARM PAD FLAG
124
NO
130
IS PAD FLAG ARMED
YES
140
ALARM
NO
TIMER≅2.5 SECONDS
126
GO TO START
128

FIG. 9


150
150
156
11A
152
PAD
TIMER
MICROPROCESSOR
154
158
94

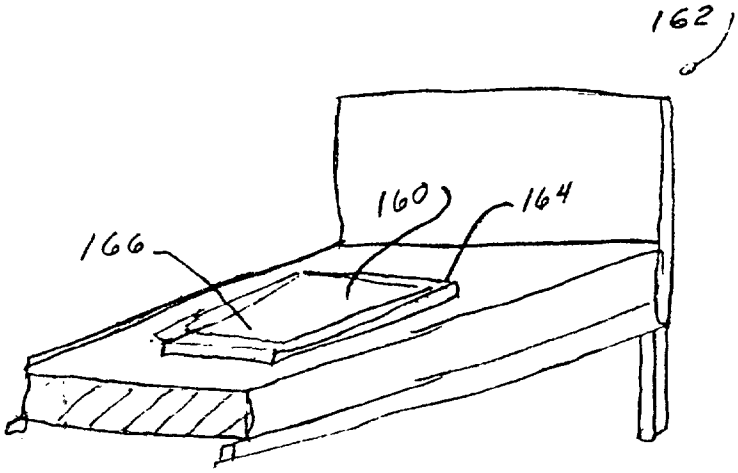


FIG. 10

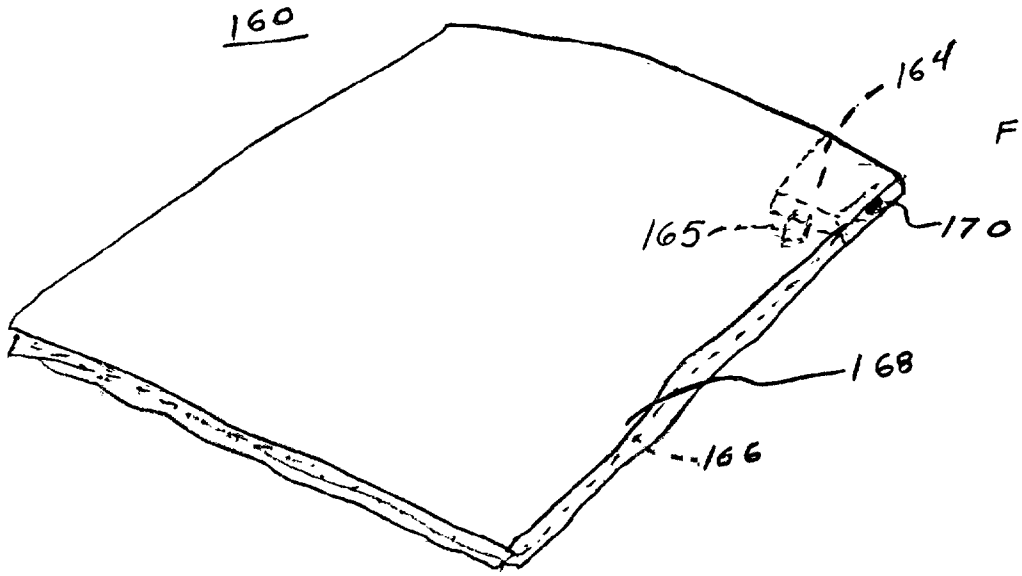


FIG. 11

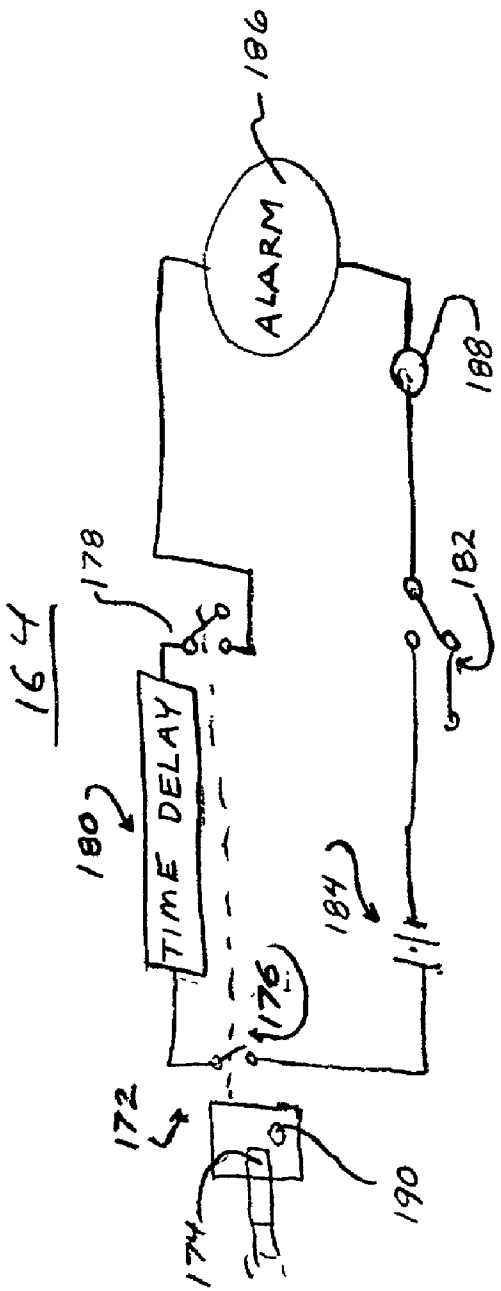

164
ALARM
196
188
178
182
TIME DELAY
180
184
175
172
174
190

FIG. 12

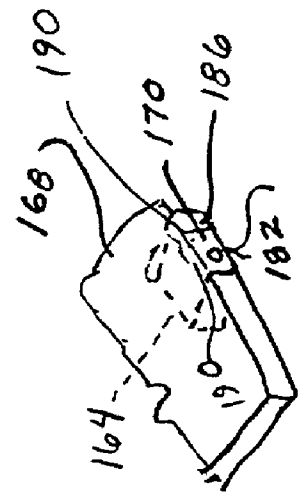

190
186
170
168
182
164
190

FIG. 13

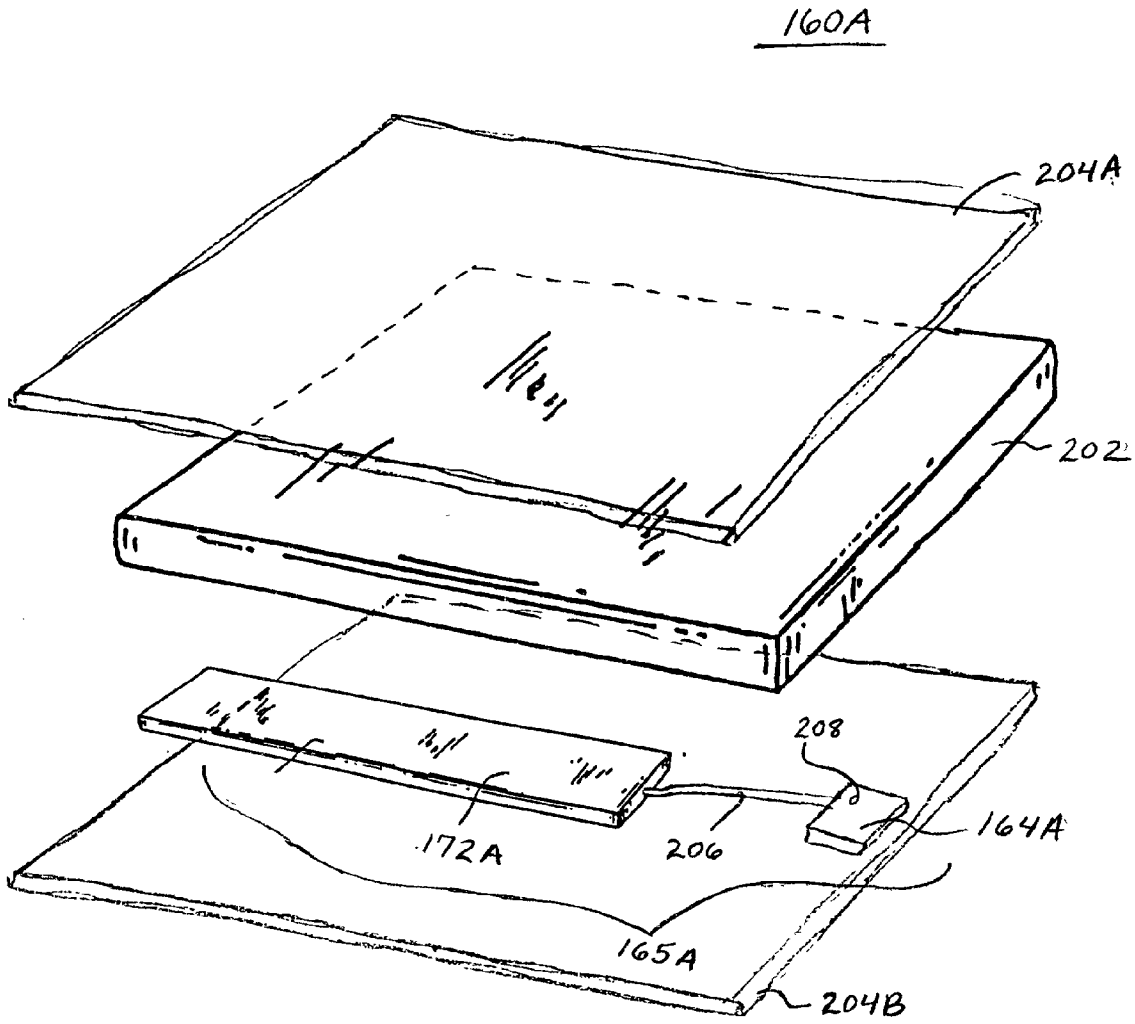


FIG. 14

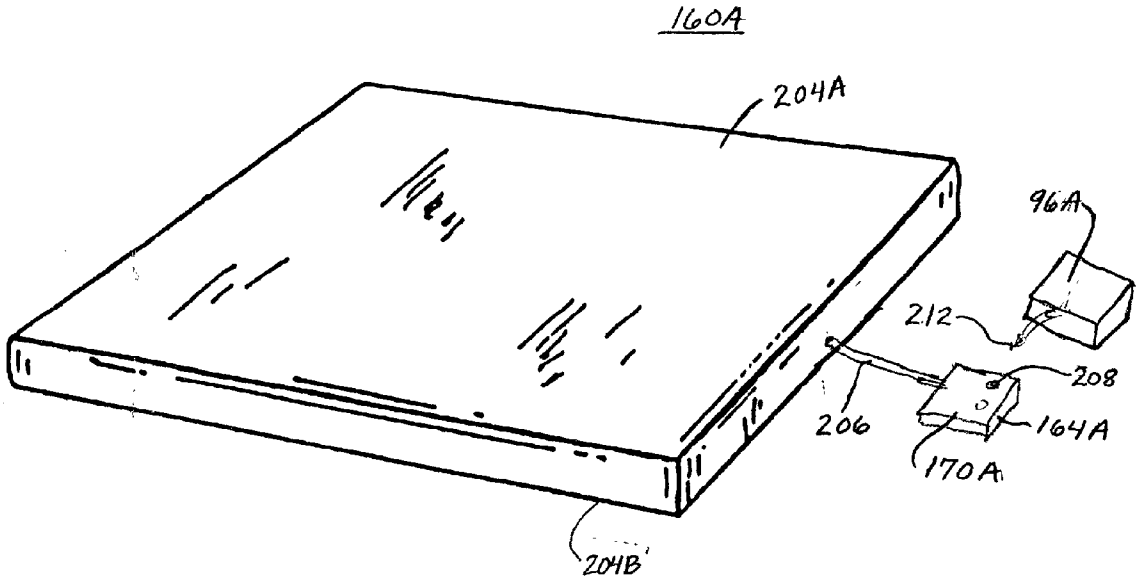


FIG. 15

PATIENT MONITORING SYSTEM

RELATED CASES

[0001] This application is a continuation-in-part application of U.S. application Ser. No. 09/151,020 filed Sep. 10, 1998, by inventor, Kristin Robert Stroda, for the invention entitled PATIENT MONITORING SYSTEM.

BACKGROUND OF THE INVENTION

[0002] This invention relates to patient monitoring systems in which the movement or location of a patient is determined by one or more sensors at least one of which is a pressure sensitive sensor.

[0003] In some systems of this type, the movement or location of a patient is determined by any of a plurality of redundant or cooperating sensors. When one or more of the sensors indicates the existence of a problem concerning the patient, the patient monitoring system provides an alarm or a warning. In other systems, a single sensor detects an unauthorized location, movement or position of the patient and provides an alarm.

[0004] In one class of these patient monitoring systems, a sensor indicates the departure of a patient from his or her expected position and the system responds by providing an alarm. In one such system, a cord or other fixed length member has a fastener on one end and an activator on the other end and the activator is connected to a monitoring housing so that if the fastener moves beyond the fixed length, the monitoring housing is activated. The fastener is connected to a patient such as to the clothing of a patient by a clip so that, if the patient moves beyond the fixed distance such as by slumping from a wheelchair onto the floor or moving from a bed, the monitoring housing provides an alarm.

[0005] In a prior art monitoring system of this type, the end of the cord having the activator opposite to the fastener is loosely fitted into the monitoring housing so that when the patient moves away from the monitoring housing a distance greater than the length of the cord, the activator is pulled free. When the activator is pulled free from the monitoring housing, an alarm is given. Prior art systems of this type are disclosed in U.S. Pat. Nos. 4,577,185, 4,858,622, and 4,583,084 and systems of this type are on sale under the trademark, TABS, by Wanderguard, Inc., a division of Senior Technologies, Inc., located at 1620 North 20th Street, P.O. Box 80238, Lincoln, Nebr. 68503.

[0006] This type of prior art patient monitoring system has several disadvantages, such as for example: (1) from time to time the fastener falls loose from the patient or is removed by the patient so that the system fails; (2) the patient may become entangled in bedding or the like or fall from the bed or chair or partly fall at a distance that does not pull the cord free; and (3) the cord may break or be cut.

[0007] In another class of patient monitoring systems, the patient in a bed or a wheelchair rests on or near a pressure pad. Changes in pressure on that pad cause a signal indicating that the patient is moving in a manner that indicates some type of problem. In a prior art monitoring system of this type, a manual switch is activated by an attendant or patient when the patient is in place to initiate the monitoring system and inactivated when the patient leaves in an ordinary non-troublesome manner. One such prior art system is disclosed in U.S. Pat. No. 4,907,845.

[0008] This type of prior art monitoring system has several disadvantages such as for example: (1) the switch may be accidentally thrown or thrown by a patient intending to move but for whom it is undesirable to move unattended because of confusion of the patient or illness to the extent that the patient does not appreciate; (2) because the pressure pad is positioned in the bed beneath the patient, it flexes as the patient moves, causing the cord to flex, eventually fail and thus prevent the signal being given if the patient leaves; (3) the pad may be defeated by folding or placing a weight on it; and (4) some of the pressure pads are expensive to purchase and maintain.

[0009] Some prior art pressure pads are relatively expensive. In the prior art the pressure pads are intended to be used for an extended period of time and may be used in connection with several patients. This type of pressure pad and method of use has several disadvantages such as: (1) it is subject to cross contamination in some cases, or in the alternative, requires relatively expensive pads to be discarded and new pads used when the patient is discharged from the facility; (2) the battery becomes faulty if it is battery operated; and (3) the battery must be checked and replaced to avoid an accidently inoperative system from being used.

SUMMARY OF THE INVENTION

[0010] Accordingly, it is an object of the invention to provide a novel patient monitoring system.

[0011] It is a still further object of the invention to provide a novel pressure pad sensor that can be used in conjunction with other sensors to monitor a patient.

[0012] It is a still further object of the invention to provide a novel disposable pressure sensor for monitoring patients.

[0013] In accordance with the above and further objects of the invention, a novel patient monitoring system is provided with one or more sensing modalities that alone or in cooperation with each other offer greater reliability. A novel disposable sensor is also provided that may be used in the novel patient monitoring system or alone. In this system of monitoring patients, an alarm or instructions to the patient are given when the patient assumes a dangerous position. The alarm signal is provided to the caretaker such as at a nurses station and a voice message is announced in the vicinity of the patient, when the patient assumes the dangerous position. The sensor may be armed by the application of weight to it and a signal may be provided to a caretaker, when the weight is removed or another sensor detects an alarm condition such as motion beyond a predetermined distance.

[0014] The patient monitoring system of this invention has several advantages, such as for example: (1) it provides redundancy so that if one alarm fails the other may succeed to provide a warning alarm; (2) it permits the selection of one or more sensing conditions and combinations of different types of sensors such as one that locates the distance that the patient has moved and another that indicates that the patient has lifted himself or herself off of a pressure pad or has swung his or her legs over the edge of a bed or applied a substantial amount of his or her weight to a support for

lifting his or herself from a bed or wheelchair; (3) it can detect distress conditions that might otherwise be missed such as for example a cord indicating a patient is leaving the bed or wheelchair or has fallen from it and a release-of-pressure sensor that indicates the patient may be thrashing about within the length of the cord or dangling from the bed or chair without exceeding the length of the cord; (4) it is difficult for the patient to defeat; (5) it is relatively flexible in the condition or conditions to be sensed and the nature of the alarm or alarms, or the warnings or messages to the patient, or the sequence of the alarms and messages and the location or locations of the alarm with respect to the care-taker of the patient; and (6) an inexpensive disposable pressure pad may be used to permit disposal after each patient and the use of a new pressure pad.

SUMMARY OF THE DRAWINGS

[0015] The above noted and other features of the invention will be better understood from the following detailed description when considered in connection with the accompanying drawings, in which:

[0016] **FIG. 1** is a simplified perspective view of an embodiment of the invention;

[0017] **FIG. 2** is a block diagram of a patient monitoring system in accordance with the invention;

[0018] **FIG. 3** is a fragmentary, simplified perspective view showing a manner in which the fastener, a cord and pressure pad are used to monitor a patient;

[0019] **FIG. 4** is a fragmentary simplified perspective view illustrating the use of the patient monitoring system in connection with a wheelchair;

[0020] **FIG. 5** is a simplified, perspective, fragmentary view illustrating the use of the patient monitoring system in connection with a bed;

[0021] **FIG. 6** is a simplified partly perspective and partly schematic view of a portion of the embodiment of **FIG. 1**;

[0022] **FIG. 7** is a block diagram of the control system for an embodiment of the invention;

[0023] **FIG. 8** is a flow diagram of the program for determining an alarm condition using a pressure pad;

[0024] **FIG. 9** is a schematic block diagram of a threshold circuit for the pressure pad;

[0025] **FIG. 10** is a fragmentary perspective of a disposable pressure pad positioned on a bed to monitor patients in accordance with an embodiment of the invention;

[0026] **FIG. 11 a** fragmentary perspective view of a disposable pressure pad in accordance with an embodiment of the invention;

[0027] **FIG. 12** is a schematic circuit diagram of a control unit used in an embodiment of pressure pad;

[0028] **FIG. 13** is a fragmentary perspective view of a portion of the pressure pad of **FIG. 11**;

[0029] **FIG. 14** is an exploded perspective view of another embodiment of a pressure pad; and

[0030] **FIG. 15** is a perspective view of the embodiment of **FIG. 14**.

DETAILED DESCRIPTION

[0031] In **FIG. 1**, there is shown a simplified perspective view of a patient monitoring system **10** having a wheelchair pressure pad switch **11**A a bed pressure pad switch **11**B. a cord **60** and a housing **13**. A microprocessor (not show in **FIG. 1**) within the housing **13** is electrically connected to either one of the wheelchair or bed pad pressure switches **11**A and **11**B (first sensor) to cooperate with them and receive a signal when pressure is applied to the pads or released from the pads. The cord switch **34** (second sensor) includes a clip such as a badge or alligator clip **12**, a cord **60** and a magnetic shunt **63** adapted to fit into a slot **67** in the housing **13**. The clip such as a badge or alligator clip **12** is on one end of the cord **60** and the shunt **63** on the other.

[0032] The alligator clip or other connector **12** is fastened to the clothing of the patient and the disk **63** put into the slot **67**. When it is removed such as by the person moving a distance greater than the length of the cord **60**, an alarm and/or voice is sounded. Similarly, when pressure is placed on either the pad **11**A in a wheelchair embodiment or the pad **11** B in a bed near the shoulders of a patient, a flag on the microprocessor is set so that when the patient releases the pressure such as by getting up from the seat of the wheelchair or sitting up if on a bed, the microprocessor receives a signal resulting in an alarm or voice message and alarm.

[0033] To establish the electrical connections between the pressure pads and microprocessor or to pulse forming equipment or threshold equipment for processing signals for input to the microprocessor within the housing **13**, the pressure pad **11**A is connected by an electrical conductor **65**A to the conductor **30** and the bed pressure pad switch **11**B is connected by a conductor **65**B to conductor **30** with the conductor **65**A being shown connected to the conductor in **FIG. 1**. The input circuits for the microprocessor may be incorporated within the housing **13** and its role is to develop a signal for the microprocessor when pressure is applied on the pressure pads **11**A and **11**B, which in the preferred embodiment is a pad that reduces resistance when pressure is placed upon it. Other types of pressure pads are known in the art and any of them may be used but some of them would not require the input circuit **15** but would generate their own signal.

[0034] In the preferred embodiment, the pressure pads are described in U.S. Pat. No. 5,796,059 to Stephen Boon which are manufactured and available from Senior Technologies, Inc., 1620 North 20th Street, Lincoln, Nebr. 68503, but other types are known such as those disclosed by U.S. Pat. Nos. 4,263,586 and 4,020,482. The pressure pad described in the aforementioned U.S. Pat. No. 5,796,059 is able to provide signals indicating the location on the pad of pressure and thus, with the aid of the microprocessor detect and indicate shifts in position of the patient such as tilting in a wheelchair or moving to the edge of a bed. While in the preferred embodiment the pressure pad is placed under the bedding it can be placed at other locations such as under the mattress. Moreover, it may be used with an analyzer such as a microprocessor to detect direction of movement such as whether a patient is moving toward a door or away from a door by detecting directional changes in pressure.

[0035] In this specification, a sensor includes any device which senses a position or motion or location of the patient. The term sensor not only includes the device for sensing the

position, location, movement or the like of the patient but any error correcting or redundant part of it which indicates a failure condition of the sensor itself.

[0036] For example, in U.S. Pat. No. 5,494,046, a clip such as a badge or alligator clip is disclosed attached to a cord and a magnetic shunt similar to that of the preferred embodiment of this invention. However, the clip such as a badge or alligator clip is designed so that while it is fastened to the garment of the patient, it in itself has an open circuit but when removed, it has a closed circuit so that if this particular sensor has been removed from the patient and is thus disabled to not detect if the patient moves beyond the length of the cord from the housing **13**, a signal nonetheless will be provided. However, in this specification it is considered one sensor because it indicates the length of the patient from the housing **13** or the failure of the sensor to be able to detect such a position of the patient.

[0037] In **FIG. 2**, there is shown a block diagram of a patient monitoring system **10** having a first sensor **32**, a second sensor **34**, the patient-station monitoring housing **13**, a station alarm system **14**, a station control and interface system **15**, and a remote station alarm **20**. The patient-station monitoring housing **13** may include a voice record system in the manner disclosed in U.S. Pat. No. 5,494,046 for providing verbal instructions to a patient under certain sensed conditions. As in the case of the system described in U.S. Pat. No. 5,494,046, the disclosure of which is incorporated herein for reference, an alarm is given at the station with the patient and/or a nurses station before a voice carries a message to the patient so that immediately upon the sensing of an alarm condition, the attendants receive notification and can proceed to the aid of the patient.

[0038] In the preferred embodiment, the second sensor **34** is a clip such as a badge or alligator clip attached to a cord which moves an object in juxtaposition with the housing **13** such as a magnetic shunt that can be removed or a magnet that activates a reed switch, either placed inside or outside of the station alarm unit **14** and the housing **13** or any other type of sensor, many of which are described in U.S. Pat. No. 4,494,046 such as photocell sensors that senses the removal of an object from the housing **13** by uncovering a light path or a mechanical device or any of many sensing devices such that may sense the removal of an object from the interior of the housing **13** or the surface of the housing **13**. Because the other sensor develops signals with a different criteria it may be used to reset the pad. For example, the pad sensor may be reset by removing and reinserting the plug **63** into the opening **67** rather than using pressure to both reset after a signal and to arm the sensor.

[0039] The station alarm **14** may include a lamp or a buzzer or the like and the remote station **20** may be connected by wires **26** to receive an alarm such as at a remote location such as a nursing station or may have an antenna **24** which receives a signal from the station alarm or transmits a signal to other stations so as to provide an alarm at those stations. The alarms at the remote stations may also be any type of indicator such as a lamp, a buzzing sound, a ringing sound, a horn-like sound, or a voice.

[0040] While in the embodiment of **FIG. 2**, alarms are provided before the message is played both near the patient and at a remote location, the alarm nearby from the station alarm may be omitted and the signal transmitted directly to the remote station or alarm **20** or the message may be played simultaneously with either or both the station alarm **14** and remote alarm **20** or before either or both alarms. The voice system may be any standard commercial arrangement such as are now commonly used to play a fixed message. In the preferred embodiment, the voice system is a single chip, voice record/playback device Model ISD14XX sold under the trademark DAST by Information Storage Devices, Inc., 2841 Junction Avenue, Suite 204, San Jose, Calif. 95134.

[0041] In **FIG. 3**, there is shown a fragmentary, simplified perspective view of a patient **64** wearing a garment **62** and having an alligator clip or other fastener **12** fastened to the garment **62** and connected by at least one length of cord **60** to the housing **13** at the patient station constituting the second sensor which is a cord switch **34** in the embodiment of **FIG. 1** and a pressure pad **11**A and switch **15** constituting a first sensor **32**. In the preferred embodiment, the clip such as a badge or alligator clip **12** is fastened by a first length of cord **60** to a switch member (not shown in **FIG. 3**) that may be pulled from its position in the housing **13** to signal an alarm easier than the alligator clip or other fastener **12** is freed from the garment **62**. The pressure pad **11**A is intended to be on the seat of a wheelchair to provide a signal if the patient leaves the wheelchair.

[0042] The length of cord **60** should be selected for the use but should be within a range of five inches to five feet and preferably within a range of ten inches to twenty-four inches for a chair and still more preferably fifteen or eighteen inches for a chair. It should be preferably within a range of two feet to three feet for a bed and still more preferably thirty inches.

[0043] The alarm switch may be of any type, such as for example the switch disclosed in U.S. Pat. No. 4,160,972, the disclosure of which is incorporated herein by reference when used to activate an alarm when the switch is opened. To activate an alarm when a switch is closed rather than when opened, a source of power in series with the alarm and switch may be used. Moreover, a voice processor **90** (**FIG. 7**) within the housing **13** may be used with other types of systems such as that disclosed in U.S. Pat. No. 4,577,185, the disclosure of which is incorporated by reference herein, to provide an alarm when the length of cord **60** is pulled free from the housing. Thus, the cord **60** may pull a ferromagnetic member away from a reed switch or may pull a mechanical switch closed or open or may move an opaque object from or into a location between a light source and a photocell to change the state of a switch and thus activate a voice recording and one or more alarms. The alarms **14** and **20** (**FIG. 2**) may be audible or visual or both.

[0044] With this arrangement, if the patient were to move further away from the housing **13** such as by falling from a chair or leaving a bed, the cord **60** would stretch and pull the magnetic shunt **63** (**FIG. 1**) or other member, free from the slot **67** (**FIG. 1**), closing a circuit in the housing **13** to activate the alarm and/or voice recording. Moreover, if pressure were released on the pads **11**A or **11**B a signal would be given to provide an alarm.

[0045] The alligator clip or other fastener **12** is generally fastened to the torso of a patient such as on a shirt or the top part of a hospital gown or the like in the vicinity of the shoulder and the cord **60** is sized in accordance with the location of the monitoring apparatus. For example, in a

wheelchair, the cord **60** is generally 18 inches long and in a bed setting it is generally two feet long. It should be no shorter than one foot and no longer than five feet in length. The housing **13** is generally fastened to a nearby support.

[**0046**] In **FIG. 4**, there is shown a fragmentary, simplified perspective view of a wheelchair **66** showing an appropriate mounting for the housing **13** above the wheelchair with the cord **60** preferably facing upwardly and being connected to the clip such as a badge or alligator clip and magnetic disk **63** in the slot **67** of the housing **13** so that a patient in the wheelchair may have the clip **12** fastened to the patient's garment. The pressure pad **11**A is under the patient's seat so that the patient's weight is upon it. In the preferred embodiment, the cord is fifteen or eighteen inches long. If the patient then slumps forward out of the chair, the disk **63** is pulled free from the slot **67** or pressure released on the pressure pad **11**A, the housing **13** provides an alarm signal to a caretaker, preferably at a remote location. The recorded message in an embodiment of this type may request the patient to remain stationary until aid arrives.

[**0047**] In **FIG. 5**, there is shown a simplified, perspective, fragmentary view of a bed **68** equipped with a patient's station monitoring housing **13** mounted to the headboard so that a clip such as a badge or alligator clip **12** (**FIGS. 1 and 3**) can be fastened to a patient. The cord **60** has a sufficient length so that if the patient falls from the bed or attempts to leave, the cord **60** will cause either the disk **63** (**FIGS. 1 and 4**) to be pulled from the housing **13** or the pressure pad **11** B to receive less weight and generate a signal. The pressure pad is preferably under buttocks but may be anywhere else that will generate weight related signals such as under the shoulders of the patient. In either case, a message may be played requesting the patient to remain in the bed or instructions may be given to the patient and/or an alarm may be transmitted to a caretaker who can attend to the matter. In the preferred embodiment, the cord is two feet long.

[**0048**] In **FIG. 6**, there is shown a simplified, fragmentary, partly-perspective and partly-schematic view of one embodiment of the patient monitoring system **10** having the first length of the cord **60**, the station alarm **14**, the pressure pad sensor conductor **30** connected so that when the magnetic shunt **63** is pulled free from the housing **13**, the reed switch **73** closes about the power supply **69** to send a signal through the conductor **61** to the station control and interface system **15** to provide an alarm signal and when the weight on one of the pressure pads is released, a signal is sent through conductor **30** through the station control and interface system **15** to provide an alarm. The station control and interface system **15** performs the "OR" function within the microprocessor **94** (**FIG. 7**) or by a separate "OR" gate before the microprocessor.

[**0049**] In the embodiment of **FIG. 6**, the housing includes a permanent magnet or an energized electromagnet **71**, a reed switch **73**, and ferromagnetic path members **75**, **77** and **79**. The ferromagnetic path members **75**, **77** and **79** form a closed ferromagnetic circuit with the magnet **71** to close the reed switch and prevent an alarm. This ferromagnetic circuit maintains the normally open reed switch **73** in its closed position. When a ferromagnetic shunt **63** is removed and the reed switch opens an alarm is given. Of course, a normally closed switch can be used by reversing other circuit elements and other sensors can be used. With this arrangement, when the disk **63** is pulled free, a signal is transmitted to the station control and interface system **15** and the station alarm **14** to initiate the voice message and/or alarm from the voice processor **90** (**FIG. 7**) of the housing **13** (**FIGS. 1, 3, 4** and **5**) and the remote station alarm **20** (**FIG. 2**) as explained in connection with **FIG. 2**.

[**0050**] **FIG. 7** is a block diagram of the control system for an embodiment of the invention and has its principle parts a microprocessor **94**, a transmitter **98**, an alarm speaker **112**, a nurse call **96** and a voice microprocessor **90**. The microprocessor **94** is a type PIC16C54 Microcontroller sold by Microchip Technology, Inc. of Arizona. It's an 18-pin microprocessor having an input **102** for tone select, an input **104** for another tone select, an input **106** for local alert and **108** for local voice to set the microprocessor **94**.

[**0051**] With this arrangement, when an input signal is received from the conductor **30**, a flag is set in the microprocessor **94**. When a signal is received indicating a release of the pressure, the microprocessor **94** transmits an alarm signal to the nurse call station **96**, the transmitter **98** and the alarm speaker **112** within two and one-half seconds unless the pressure is again applied to the sensing pad. If set for that purpose, a signal may be sent to the voice microprocessor **90**. This provides the warning to the patient. Similarly, a signal from the station control and interface system **15** (**FIG. 6**) or similar component in other circuit arrangement from other sensors indicating that the first sensor which is the magnetic shunt **63** has been pulled free, initiates an alarm signal.

[**0052**] In **FIG. 8**, there is shown a flow diagram of a program utilizable in the microprocessor **94** (**FIG. 7**) to determine an alarm condition using a pressure pad which program includes a start step **120**, a wake-up or power starting and initializing step **122**, an alarm condition detecting step **124**, a timer step **126** and a go to start step **128**. With this arrangement, the microprocessor **94** (**FIG. 7**) is initialized such as at the step **122** and determines if there is an alarm condition caused by the shunt being removed or the pressure pad being armed and removed, determines if there is an alarm condition on the pad if it lasts for approximately 2.5 seconds and returns to start step **128**.

[**0053**] The alarm condition detecting step **124** includes the steps of determining if the shunt is pulled at step **130**, providing an alarm signal as shown at **132** if it has been pulled, and if it has not been pulled, going to the decision step **134**. The decision step **134** determines if the pad is present and if it is, the program proceeds to the arm the pad step **136** by applying a pressure pad flag if pressure has been applied to the pressure pad to reduce resistance. If the pad is not present, then the program proceeds to the decision step **138** to determine if there is an armed pad flag, and if there is, then it proceeds to the step **140** to provide an alarm. If not, it proceeds to the timer step **126** and from there back to the start step **120** from the go to start step **128**. If the armed pad flag **136** is set as a result of the pad being present and weight being upon it then the program proceeds to the timer step **126** and from there back through steps **120**, **122**, **130**, **134**, **138** and alarm step **140**. With this arrangement, an alarm is provided if the shunt is pulled or if the flag is armed and weight is removed for approximately 2.5 seconds.

[**0054**] In **FIG. 9**, there is shown a schematic block diagram of the microprocessor circuitry **94** connected to the

pad **11A**. The pad is energized by a source of voltage **150** and applied to the pad **11A** through a resistor **152**. A comparator **154** has its noninverting input terminal energized by the battery source **150** through an adjustable resistor **156** that determines a threshold value for the pad that can be set to accommodate the weight and size of a person on the pad. The pad provides the signal as determined by **150** and controlled by the resistance of the pad **11A** to the inverting terminal of the comparator **154** to initiate a timer **158**, which may be within the microprocessor or separate from the microprocessor. If this condition as determined by the comparator **154** lasts for approximately 2.5 seconds then the microprocessor provides an alarm signal. But if the threshold from the pad **11A** as applied to the comparator **154** falls at the noninverting input terminal, then the timer **158** is reset and no alarm is given.

[**0055**] In **FIG. 10**, there is shown another embodiment **160** of a pressure sensing pad resting on a bed **162** having a control unit **164**, a pressure sensor **166** and an enclosing case **168** (**168** not being numbered in **FIG. 10**). The case **168** is made of a flexible or partly flexible material that feels good to the touch such as plastic or partly plastic and partly cloth or any other materials. The control unit **164** is located in a pocket within the case **168** so that a control surface is exposed and available for setting. Otherwise, the case **168** entirely encompasses the pressure sensor **166** and seals the pressure sensor against most moisture. The pressure sensing pad **160** is intended to be disposable so that it may be used with one patient and then disposed of.

[**0056**] In **FIG. 11**, there is shown a fragmentary perspective view of one embodiment of the disposable pressure sensing pad **160** showing the enclosing case **168**, the control unit **164** and a pressure sensor **166**. In this embodiment, the pressure sensor **166** is a gel pad of the type used for patients having sensitive areas to rest upon, with one or more tubes **165** communicating with the interior of the gel pad or pads **166** and with the pressure switch in the control unit. The plastic casing **168** is sealed around the control unit **164** leaving a control face **170** exposed to permit adjustment of the amount of pressure necessary to cause an alarm to be given by the pressure sensing pad **160**. The pressure sensor **166** may remain enclosed and the amount of pressure that must be applied to it to activate it may be set by a bias adjustment manual dial **190** (**190** not being numbered in **FIG. 11**). In other embodiments, the pressure may be preset at the factory and the pressure sensing pad sold calibrated to a certain pressure. If multiple gel pads are combined into one pressure sensing pad, then multiple tubes **165** must connect to a manifold and the manifold to the pressure switch in the control unit **164**.

[**0057**] In **FIG. 12**, there is shown a schematic circuit diagram of the control unit **164** having a double-pole, single-throw pressure-activated switch **172**, a time delay circuit **180**, an audible alarm **186**, an on/off switch **182**, a battery **184**, and a lamp **188**. The double-pole, single-throw pressure-activated switch **172** has a first switch contact set **176** and second switch contact set **178** and an actuator plunger **174**. The actuator plunger **174** communicates with a pressure sensor so as to be held open when pressure beyond a preset value is placed on the pressure sensor that is beyond a preset value of pressure. This switch **172** also opens a switch contact set **178** in circuit with the time delay circuit **180** and the switch contact set **176**. This switch arrangement is in circuit with the audible alarm **186**, the lamp **188**, a single-pole double throw on/off switch **182**, and the battery **184** so that when the switch **172** is closed, the normally open switch contact sets **176** and **178** are opened by pressure to open the circuit that includes the battery **184**, the audible alarm **186** and the lamp **188**. The on/off switch **182** is a third switch that may open the circuit.

[**0058**] When the on/off switch **182** is closed and there is no pressure upon the pressure sensor, the circuit is completed through the normally open switch contact sets **176** and **178**, the time delay circuit **180**, the alarm **186**, the lamp **188**, the on/off switch **182** and the battery **184** so that the lamp **188** is illuminated and the alarm **186** given. When pressure is applied to the pressure sensor beyond a preset amount as set by the bias adjustment manual dial **190**, the circuit is broken, or if the circuit is turned off by the on/off switch **182**, the circuit is broken. If the on/off switch **182** is closed and pressure is removed from the double-pole, single-throw pressure-activated switch **172**, a signal is sent through the time delay **180**. If the switch **172** remains inactivated, the signal passes through the switch contact set **178** and the alarm **186** sounds and the lamp **188** is illuminated. However, if while the circuit signal is passing through the time delay circuit **180**, pressure is again applied to the pressure sensor, then the switch contact set **178** is open and no alarm is given. With this arrangement, if the pressure sensing pad **160** is placed on a wheelchair or a bed and energized by closing the on/off switch **182**, the pressure will open the switch contact sets **176** and **178** so there will be no alarm. However, if the patient leaves the seat or the bed, the normally open switch contact sets **176** and **178** will close and if they remain closed after the time of the time delay circuit **180**, the alarm **186** will sound and the lamp **188** will be illuminated unless the on/off switch **182** is open. The switch **172** includes an actuator plunger **174** which may be in physical contact with the interior of the pad and which is adjustable by the bias adjustment manual dial **190**. This sensor may be similar to the sensor in U.S. Pat. No. 4,336,533.

[**0059**] In **FIG. 13**, there is shown a fragmentary perspective view of the control unit **164** within the case **168**, with the case **168** sealed to the control face **170** leaving exposed the lamp **188**, the speaker of the alarm **186**, the bias adjustment manual dial **190** and the on-off switch **182**. With this arrangement, the activating pressure may be set to accommodate different weight patients by the bias adjustment manual dial **190**. The on-off switch **182** is accessible to control the pressure sensing pad **160**, and the lamp **188** (**FIG. 12**) and alarm **186** are easily seen and heard.

[**0060**] When a preset time period is near its end or a patient is discharged and it's desirable to dispose of the pressure pad and provide a new one for a new patient, the plastic casing may be torn to indicate that the disposable pad is to be discarded and may be discarded in whatever provision is made within the nursing home or hospital for discarding such used disposable items. Thus when a new patient is admitted, a new pad may be used with the patient and assigned to the patient so that there will be no cross contamination between patients. The pads have a preset life and if that life is exceeded, then the pad is changed and a new pad is assigned to that patient. When the patient is discharged, the pad is discarded.

[0061] While a gel pad of the type sold by Deka Medical, Inc. P.O. Box 2426, Columbus, MS 39704 under the trademark Gel-Lite is desirable, combined with the pressure switch such as that disclosed in U.S. Pat. No. 4,336,533, other types of pressure sensitive pads and switch mechanisms may be used. For example, the switch mechanism described above may be used and this pad may be incorporated as part of the multiple sensor configuration described in this application. Similarly, other pads may be utilized although because the pad is disposable, it is desirable that inexpensive types of sensing pads be used.

[0062] In **FIG. 14**, there is shown an embodiment of a disposable pressure sensing pad **160**A having a commercial gel pad **202**, a vinyl cover shown at **204**A and **204**B and a sensor **165**A. The sensor **165**A may be of the type disclosed in U.S. Pat. No. 5,990,799 issued Nov. 23, 1999, to Boon et al having a pressure activating switch **172**A, an electrical cord **206** and a control unit **164**A containing an alarm and jack socket **208** for receiving a nurse call of the type sold by Senior Technologies, Inc., 1620 North 20th Street, Lincoln, Nebr. 68503, under the trademark, Arial nurse call.

[0063] In **FIG. 15**, there is shown a perspective view of a disposable pressure sensing pad **160**A completely assembled to be entirely covered by a vinyl cover **204**A and **204**B and having the cord **206** extending from it. The vinyl cover **204**A and **204**B may be a continuous vinyl pouch integrally formed to be sealed at one end or may be in sections sealed after the sensing pad has been positioned in place. The control unit **164**A has a face **170**A to indicate the condition of the battery, an alarm and a jack socket **208** for receiving a nurse call unit **96**A containing a jack **212** to be inserted in the jack socket **208**. With this arrangement the pad **160**A may be discarded after a patient is discharged or if it becomes soiled, saving the nurse call unit **96**A and in some embodiments the control unit **164**A which may be connected to the cord **206** by means of a jack socket **208**.

[0064] The patient monitoring system of this invention has several advantages, such as for example: (1) it provides redundancy so that if one alarm fails the other may succeed to provide a warning alarm; (2) it permits the selection of one or more sensing conditions and combinations of different types of sensors such as one that locates the distance that the patient has moved and another that indicates that the patient has lifted himself or herself off of a pressure pad or has swung his or her legs over the edge of a bed or has applied a substantial amount of his or her weight to a support for lifting his or herself from a bed or wheelchair; (3) it can detect distress conditions that might otherwise be missed such as for example a cord indicating a patient is leaving the bed or wheelchair or has fallen from it and a release-of-pressure sensor that indicates the patient may be thrashing about within the length of the cord or dangling from the bed or chair without exceeding the length of the cord; (4) it is difficult for the patient to defeat; (5) it is relatively flexible in the conditions to be sensed, the nature of the alarm or alarms or the warnings or messages to be given, the sequence of the alarms and messages and the location or locations of the alarm with respect to the caretaker or the patient are selectable; (6) it is economical so that it may be entirely or partly disposed of between patients or if it becomes soiled; and (7) it can be connected to other units such as a nurse call system for increased flexibility of use.

[0065] Although a preferred embodiment of the invention has been described with some particularity, many modifications and variations of the preferred embodiment are possible within the light of the above teachings. Therefore, it is to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described.

What is claimed is:

1. A method of monitoring a patient, comprising the steps of:

placing a pressure pad that is encased in a cover on a resting place for the patient;

energizing the pressure pad, whereby a signal is provided responsive to pressure placed on the pressure pad by the patient;

arming the pressure pad when a predetermined weight is on the pressure pad whereby the pressure pad serves as a sensor;

activating an alarm when the predetermined weight is removed from the armed pressure pad; and

disposing of the pressure pad when the patient no longer has use of the pressure pad.

2. A method according to claim 1 wherein the pressure pad is a first sensor and a second sensor is placed in juxtaposition with the patient so that when the patient assumes a dangerous position as indicated by the second sensor an alarm signal is given, a monitoring station is activated when the alarm signal is provided, and a voice message is announced near the patient.

3. A method in accordance with claim 1 wherein an alarm is provided to a caretaker.

4. A method in accordance with claim 1 wherein the alarm is near the patient.

5. A method in accordance with claim 1 wherein the alarm is at a remote station.

6. A method of monitoring a patient in accordance with claim 1 wherein the cover is plastic and is torn when the pressure pad is to be disposed of.

7. A method of monitoring a patient, comprising the steps of:

placing a pressure pad under the patient that activates a first switch when it is energized;

attaching a fastener to the patient, wherein if the patient moves beyond a predetermined distance, a second switch moves between one of an open state or a closed state to the other of the open or closed state; and

providing an alarm signal when either the first switch or the second switch is activated wherein the pressure pad is activated by removal of pressure and reset by application of pressure.

8. A method in accordance with claim 7 wherein the fastener is attached to clothing of the patient.

9. A method in accordance with claim 7 further including the step of providing a verbal message to the patient.

10. A method in accordance with claim 7 further including the step of transmitting a signal to a remote station and providing an alarm to a caretaker at the remote station.

11. Apparatus for monitoring a patient, comprising:

a pressure pad for providing a signal indicating a pressure condition;

a control housing connected to and located adjacent to the pressure pad and responsive to the signal; and

a casing at least partly encasing the control housing and the pressure pad.

12. Apparatus for monitoring a patient in accordance with claim 11 in which the pressure pad is activated by removal of pressure and inactivated by application of pressure.

13. Apparatus in accordance with claim 11 further including a recorded voice message sounding within hearing distance of the patient.

14. Apparatus in accordance with claim 11 wherein the pressure pad responds to pressure by reducing electrical resistance between a first point and a second point, said apparatus including a switch armed upon the reduction of electrical resistance and an alarm for providing the alarm when the switch has been armed and the electrical resistance is under a predetermined resistance threshold for more than 1 second, wherein a movement of the patient from the pressure pad triggers the alarm.

15. A patient monitoring system according to claim 14 in which the alarm provides the alarm when the switch has been armed and electrical resistance is under the predetermined resistance threshold for a time between 2 seconds and 3 seconds in duration.

16. A pressure pad comprising:

a gel cushion;

an alarm system having a pressure switch and an alarm;

said pressure switch being in communication with said gel cushion, whereby pressure on the gel cushion results in pressure on the pressure switch;

said alarm being connected to said pressure switch to be controlled thereby; and

said alarm system being activated by pressure on the pressure switch.

17. A pressure pad according to claim 16 wherein the alarm system is armed upon pressure being placed on the pressure pad and activated upon a release of the pressure if said pressure is removed longer than a predetermined time after the alarm is activated.

18. A pressure pad according to claim 17 in which the alarm is a visible alarm.

19. A pressure pad according to claim 17 in which the alarm is an audible alarm.

20. A pressure pad according to claim 17 in which the pressure switch includes two conductors spaced by a flexible material that permits contact between the conductors under a predetermined amount of pressure.

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