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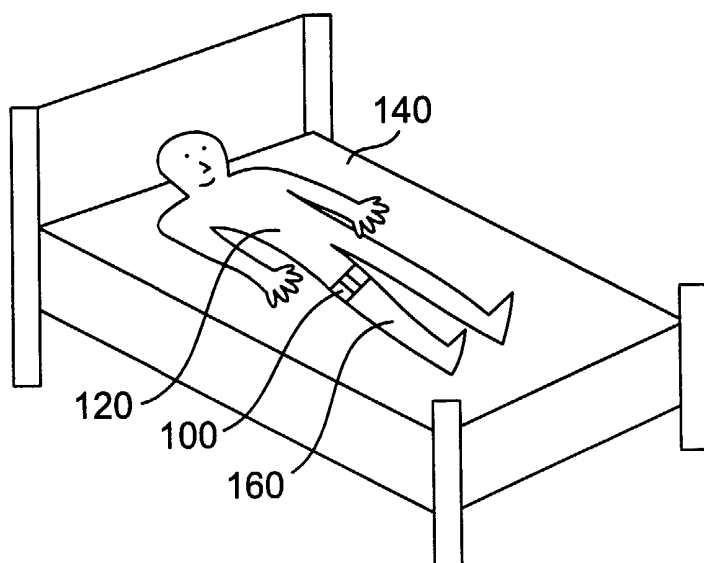
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(54) Title: APPARATUS AND METHOD FOR DETECTING AN INCLINATION OF A BODY



(57) Abstract: The present invention comprises an apparatus (100) and method for detecting an inclination of a body. The invention can provide a care giver information concerning the inclination of the body of a person (120) in the care giver's care. The present invention is especially useful in warning of possible falls in cases where a person (120) who is mentally or physically disabled attempts to rise from a bed (140) or a chair (200). The present invention comprises at least two tilt switches (500, 600) where one tilt switch (500, 600) is capable of detecting when the apparatus (100) of the invention has been inclined in an amount greater than a preselected inclination angle. The apparatus (100) also comprises an alarm signaling device (340, 400) that is capable of sending the alarm signal to alert a care giver.



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APPARATUS AND METHOD FOR DETECTING
AN INCLINATION OF A BODY

5 TECHNICAL FIELD OF THE INVENTION

The present invention is directed to an apparatus and method for detecting an inclination of a body. The invention can provide a care giver information concerning the inclination of the body of a person in the care giver's care. The present invention is especially useful in warning of possible falls where a person who is mentally or physically disabled attempts to rise from a bed or a chair.

BACKGROUND OF THE INVENTION

15 It is estimated that as many as five million (5,000,000) persons in the United States suffer from cognitive decline. Alzheimer's disease and senile dementia are the major causes of cognitive decline. Alzheimer's disease is estimated to afflict between three million (3,000,000) and four million (4,000,000) persons. Senile dementia afflicts the majority of the remainder of those persons who suffer from cognitive decline. Some persons may suffer a temporary cognitive decline due to illness and recover their cognitive faculties when they recover from the illness.

25 Alzheimer's disease is caused by the formation of amyloid plaques of protein that disrupt normal neural activity. Many persons who get Alzheimer's disease begin to experience the onset when they are in their sixties.

30 Senile dementia is caused by a number of different factors that are related to brain aging and geriatric diseases. Many persons who get senile dementia begin to experience the onset when they are in their seventies and eighties.

An estimated fifteen percent (15%) of people who suffer from cognitive decline are in institutions such as hospitals, nursing homes or similar institutions. The procedures that are used in such institutions are specifically designed to closely monitor persons who are suffering from cognitive decline.

However, most of the people who suffer from cognitive decline are not institutionalized but are cared for at home. It is estimated that as many as ten percent (10%) to twenty percent (20%) of these cases are in the advanced stages of cognitive decline.

Persons who are in the advanced stages of cognitive decline are very likely to be unable to prevent themselves from falling when they attempt to rise from a bed or a chair. The same is true for persons who are suffering from either temporary or permanent physical decline. For example, a person who has suffered a stroke or who has broken a leg may have a similar risk of falling when they attempt to rise from a bed or a chair.

In order to prevent such persons from falling, it would be advantageous to have an apparatus and method that could alert a care giver whenever a person who suffers from cognitive or physical decline attempts to rise from a bed or a chair.

Until fairly recently institutions and some individual care givers physically prevented patients with severe mental or physical disabilities from rising from a bed or a chair without assistance. This was usually achieved with the aid of physical restraints. The use of physical restraints has now generally fallen into disfavor. Many states and municipalities are now establishing new laws that prevent the use of physical restraints except in extreme cases. Many institutions have now begun to establish new procedures and monitoring systems to protect

patients from falls that do not require the use of physical restraints. A major deficiency of the physical restraint system was that it could not provide the care giver with notice that the physically restrained patient desired assistance or desired to rise from his or her bed or chair.

Some prior art patient motion detectors use electrically wired pressure sensitive pads placed on beds or chairs. When the patient who is in the bed or on the chair begins to get up, the pressure sensitive pad electrically senses the decrease in weight in the bed or chair. This approach requires the use of one or more electrically wired pads and requires pads having a size sufficiently large to cover the area of the bed or chair. The wired pads require an initial investment to purchase and install them. The wired pads also require maintenance costs because the wired pads need to be cleaned frequently.

Another example of a prior art patient motion detector is a simple clip on an extended non-restraining cord. The clip is attached to the back of the patient's garment and the cord is attached to an alarm for alerting the care giver. When the patient attempts to rise from the bed or chair (or otherwise move an extended distance), then the extension of the cord to the cord's limit pulls on the alarm and alerts the care giver that the patient is attempting to move past the cord's limit. A major problem with the clip-cord system is that the cord can easily become entangled in bedding or clothing. Another major problem is that the clip can become detached from the patient as the patient moves around in the bed or chair.

Prior art physical restraint systems have generally lost societal acceptance. The other prior art patient monitors described above have one or more problems or limitations in the areas of ease of use, reliability, and alerting and summoning care givers for assistance.

There is therefore a need for an improved apparatus for detecting patient motion when a patient changes position and moves from a lying position or a sitting position to a potentially unsafe vertical standing position. There is also a need for an improved apparatus for alerting a remotely located care giver that a patient has changed position and moved from a lying position or a sitting position to a potentially unsafe vertical standing position.

In an institutional setting, there is a need for an improved apparatus for detecting which patient of a plurality of patients has changed his or her position and moved from a lying position or a sitting position to a potentially unsafe vertical standing position.

In an institutional setting, there are cases where it is important to know whether a patient who is supposed to be standing or sitting has changed his or her position and is now lying down. Therefore there is a need for an improved apparatus for detecting patient motion when a patient moves from a standing position or a sitting position to lying position.

A potentially unsafe sleeping position for very small children is that of sleeping on the stomach. A very small child should sleep on his or her back in order to reduce the risk of Sudden Infant Death Syndrome. There is therefore a need for an improved apparatus and method for detecting the motion of a child to determine when a sleeping child rolls over onto its stomach.

For these and many other applications an improved apparatus and method is needed for detecting the inclination of a body.

SUMMARY OF THE INVENTION

The present invention is directed to an apparatus and method for detecting an inclination of a body. The invention can provide a care giver information concerning the inclination of the body of a person in the care giver's care. The present invention is especially useful in warning of possible falls where a person who is mentally or physically disabled attempts to rise from a bed or a chair.

The apparatus of the invention comprises at least two tilt switches connected in series or in parallel that are capable of detecting when the apparatus has been inclined with respect to a reference plane in an amount greater than a preselected inclination angle. In an advantageous embodiment of the present invention, the apparatus is attached to the leg of the person in a bed or a chair. The apparatus can detect when the person has risen from the bed or the chair and is in a standing position.

A person in a bed can roll over to the left one hundred eighty degrees (180°) or to the right one hundred eighty degrees (180°). In an advantageous embodiment of the present invention, a second tilt switch in series with a first tilt switch causes the alarm to not sound erroneously when the person rolls over in bed.

When the body of a person becomes inclined with respect to a reference plane in an amount greater than a preselected inclination angle (e.g., by standing up from a bed or a chair), the tilt switches in the apparatus generate a signal that indicates that the inclination angle limit has been exceeded and sends the signal to a controller. The controller receives the signal from the tilt switches and causes a radio frequency transmitter to transmit an alarm signal to a base station that is monitored by a care giver. Alternatively, the controller

transmits the alarm signal to a sound alarm that is capable of causing an audio speaker to make a loud audible sound.

In either case, the care giver is thereby immediately notified that the person to whom the apparatus is attached
5 has changed his or her position in a manner that exceeds the preselected inclination angle. The care giver is then able to respond to what could become an unsafe situation. Many falls occur after a person has arisen from a bed or a chair and taken a few steps. The relatively immediate
10 arrival and assistance of the care giver in such a situation greatly reduces the likelihood that the person will fall. The loud audible sound of the alarm signal may also provide a reminder to the person that he or she should not be standing or attempting to walk.

15 It is a primary object of the present invention to provide an apparatus and method for detecting an inclination of a body in order to give a care giver information concerning the inclination of the body of a person in the care giver's care.

20 It is also an object of the present invention to provide an apparatus and method for detecting an inclination of a body when a person is attempting to rise from a bed or a chair.

25 It is a further object of the present invention to provide an apparatus and method for notifying a care giver when a person in the care giver's care is attempting to rise from a bed or a chair.

30 It is a further object of the present invention to provide an apparatus and method for notifying a care giver when a person in the care giver's care who has been standing lies down in a bed or sits down in a chair.

It is another object of the present invention to provide an apparatus and method for detecting the motion of

a child to determine when a sleeping child has rolled over onto its stomach.

5 It is an object of the present invention to provide an apparatus and method for monitoring the status of a person who suffers from cognitive or physical decline when that person is in a bed or a chair.

10 It is also an object of the present invention to provide an apparatus and method for sending coded messages to a care giver who simultaneously monitors the status of several persons who suffer with cognitive or physical decline to provide the care giver with information concerning the status of persons and concerning the operational status of the apparatus.

15 The foregoing has outlined rather broadly the features and technical advantages of the present invention so that those skilled in the art may better understand the detailed description of the invention that follows. Additional features and advantages of the invention will be described hereinafter that form the subject of the claims of the invention. Those skilled in the art should appreciate that
20 they may readily use the conception and the specific embodiment disclosed as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. Those skilled in the art should also
25 realize that such equivalent constructions do not depart from the spirit and scope of the invention in its broadest form.

30 Before undertaking the Detailed Description, it may be advantageous to set forth definitions of certain words and phrases used throughout this patent document: the terms "include" and "comprise" and derivatives thereof mean inclusion without limitation; the term "or," is inclusive, meaning and/or; the phrases "associated with" and "associated therewith," as well as derivatives thereof, may

mean to include, be included within, interconnect with, contain, be contained within, connect to or with, couple to or with, be communicable with, cooperate with, interleave, juxtapose, be proximate to, be bound to or with, have, have
5 a property of, or the like; and the term "controller" means any device, system or part thereof that controls at least one operation, such a device may be implemented in hardware, firmware, or software, or some combination of at least two of the same. In particular, a controller may be
10 a data processor capable of executing an application program stored in a memory, such as a random access memory (RAM), coupled to the data processor. It should be noted that the functionality associated with any particular controller may be centralized or distributed, whether
15 locally or remotely. Definitions for certain words and phrases are provided throughout this patent document. Those of ordinary skill in the art should understand that in many, if not most, instances, such definitions apply to prior, as well as future uses of such defined words and
20 phrases.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, wherein like numbers designate like objects, and in which:

FIGURE 1 is a drawing showing a person lying in a bed who is wearing the apparatus of the present invention; and

FIGURE 2 is a drawing showing a person sitting in a chair who is wearing the apparatus of the present invention; and

FIGURE 3 is a block diagram of the present invention showing the interconnection of a tilt switch unit and a controller and a transmitter and an antenna; and

FIGURE 4 is a block diagram of the present invention showing the interconnection of a tilt switch unit and a controller and a sound alarm and an audio speaker; and

FIGURE 5 is a schematic drawing of one embodiment of a tilt switch capable of being used in the tilt switch unit of the present invention; and

FIGURE 6 is a schematic drawing of an alternate embodiment of a tilt switch capable of being used in the tilt switch unit of the present invention; and

FIGURES 7a-7d are schematic drawings of the tilt switch unit of the present invention showing a first tilt switch in series with a second tilt switch in four different orientations; and

FIGURE 8 is a schematic drawing of tilt switch unit of an advantageous embodiment of the present invention showing a first tilt switch in parallel connection with a second tilt switch and in parallel connection with a third tilt; and

FIGURE 9 is a detailed circuit diagram showing the interconnection of the two tilt switches and the controller of the present invention; and

5 FIGURE 10 is a detailed circuit diagram of a transmitter for use with the present invention; and

FIGURE 11 is a flow diagram describing the logic of the operation of an advantageous embodiment of the present invention.

DETAILED DESCRIPTION

FIGURES 1 through 11, discussed below, and the various embodiments used to describe the principles of the present invention in this patent document are by way of illustration only and should not be construed in any way to limit the scope of the invention. Those skilled in the art will understand that the principles of the present invention may be implemented in a suitably modified apparatus for detecting an inclination of a body.

FIGURE 1 is a drawing illustrating how apparatus 100 of the present invention may be worn by a person 120 lying on a bed 140. Person 120 in FIGURE 1 is wearing apparatus 100 of the present invention on leg 160. Apparatus 100 may be worn under or over the clothes of person 120. Apparatus 100 may also be placed in a pocket (not shown) of the clothes of person 120 as long as apparatus 100 is appropriately aligned and positioned within the pocket. When person 120 is lying on bed 140 as shown, apparatus 100 is aligned with the level of bed 140. As will be seen from the discussion below, apparatus 100 does not detect an inclination of leg 160 of person 120 when leg 160 is raised vertically with respect to the level of bed 140. Apparatus 100 detects an inclination of leg 160 of person 120 when leg 160 is lowered from the level of bed 140. When person 120 is standing, the inclination of leg 160 is approximately vertical with respect to the horizontal level of bed 140.

FIGURE 2 is a drawing illustrating how apparatus 100 of the present invention may be worn by a person 120 sitting on a chair 200. Person 120 in FIGURE 2 is wearing apparatus 100 of the present invention on leg 160. When person 120 is sitting on chair 200 as shown, apparatus 100 is aligned with the horizontal level of chair 200. As will be seen from the discussion below, apparatus 100 does not

detect an inclination of leg 160 of person 120 when leg 160 is raised upwardly with respect to the horizontal level of chair 200. Apparatus 100 detects an inclination of leg 160 of person 120 when person 120 stands up from chair 200.
5 When person 120 is standing, the inclination of leg 160 is approximately vertical with respect to the horizontal level of chair 200.

FIGURE 3 is a block diagram of the apparatus 100 of the present invention showing a tilt switch unit 300
10 coupled to a controller 320. Radio frequency transmitter 340 is coupled to controller 320. Antenna 360 is coupled to transmitter 340. Battery 380 is coupled to controller 320 and supplies electrical power for the operation of controller 320. Although battery 380 is shown coupled only
15 to controller 320 in FIGURE 3 (and in FIGURE 4), battery 380 is connected to and provides electrical power to all components of apparatus 100 through other electrical connections (not shown).

Tilt switch unit 300 detects when apparatus 100 has
20 been inclined in an amount greater than a preselected inclination angle. In an advantageous embodiment of the invention the preselected inclination angle is chosen to be seventy degrees (70°). In the description that follows the value of seventy degrees will be used for purposes of
25 illustration. But it is clear that other values of inclination angle can be chosen for use with the invention.

When person 120 rises or attempts to rise from bed 140, leg 160 (to which apparatus 100 is coupled) moves into a vertical position with respect to the level of bed 140.
30 The vertical position causes the inclination angle of leg 160 to be approximately ninety degrees (90°). Ninety degrees is greater than the inclination angle limit of seventy degrees (70°) that has been preselected and set

within tilt switch unit 300. The same result occurs when person 120 rises or attempts to rise from chair 200.

When tilt switch unit 300 experiences an inclination angle that is greater than the seventy degree angle limit, tilt switch unit 300 generates an inclination signal that indicates that the inclination angle limit of seventy degrees has been exceeded. In response, tilt switch unit 300 sends an inclination signal to controller 320 to alert controller 320 that the tilt switch unit 300 is in a closed position. The inclination signal may take the form of an interrupt signal that tilt switch unit 300 sends to controller 320.

When controller 320 receives an inclination signal from tilt switch unit 300, controller 320 immediately begins to time the duration of the inclination signal. If the inclination signal from tilt switch unit 300 ends within a preselected time limit, then controller 320 ignores the inclination signal. Although any duration for the preselected time limit may be selected, for purposes of illustration the preselected time limit will be selected to be two (2) seconds. If the duration of the inclination signal exceeds the two (2) second time limit, controller 320 generates an alarm signal for radio frequency transmitter 340. Therefore, the criterion for generating an alarm signal in this example is that tilt switch unit 300 remains in a closed position for more than two (2) seconds.

When the alarm signal is received from controller 320, then radio frequency transmitter 340 transmits an alarm signal to a base station radio receiver (not shown) that is monitored by a care giver. The care giver is thereby immediately alerted that person 120 (to whom apparatus 100 is attached) has risen or is attempting to rise from bed

140 (or chair 200). The care giver is then able to respond to person 120 and prevent person 120 from falling.

After controller 320 has generated and sent an alarm signal to radio frequency transmitter 340, controller 320
5 turns off the alarm signal to transmitter 340 after a preselected time limit has elapsed. Although any duration for the preselected time limit may be selected, for purposes of illustration the preselected time limit will be selected to be two hundred fifty microseconds (250 μ s). A
10 microsecond is equal to one millionth of a second. Radio frequency transmitter 340 responds to the alarm signal from controller 320 and generates and transmits an alarm signal of longer duration through antenna 360. The duration of the longer alarm signal of transmitter 340 may be selected
15 to have sufficient length to provide adequate notice to the care giver.

After the preselected time limit of two hundred fifty microseconds (250 μ s) has elapsed controller 320 turns off the alarm signal to transmitter 340. Controller 320 is
20 then capable of generating another alarm signal when leg 160 of person 120 is again moved from a horizontal position by a vertical angle of more than seventy degrees (70°).

In an alternate embodiment of the invention, controller 320 may enable the alarm signal until controller
25 320 receives an alarm disable signal. The alarm disable signal may be manually entered in controller 320. Alternatively, the alarm disable signal may be a radio signal transmitted to a radio receiver (not shown) coupled to controller 320.

30 Controller 320 may also generate and send a unique identification code that uniquely identifies controller 320 as the source of the alarm signal. The identification code may also be transmitted with the alarm signal by transmitter 340. The identification code is useful in

institutional settings where many units of apparatus 100 (each with its own separate controller 320) are used to monitor many persons simultaneously. The institutional care giver at the base station who is monitoring many
5 different units of apparatus 100 (each with its own identification code) can use a unique identification code to immediately determine which person 120 caused an alarm signal to sound.

Controller 320 may also determine when battery 380 is
10 in a low voltage condition. If the voltage level of battery 380 is allowed to become too low, apparatus 100 will not operate. In an advantageous embodiment of the present invention controller 320 periodically determines the operating status of battery 380. For example,
15 controller 320 can determine the operating status of battery 380 at least once every twenty four hours. When controller 320 detects a low voltage condition in battery 380, controller 320 generates and sends an alarm signal that is identical to the alarm signal that controller 320
20 generates and sends when tilt switch unit 300 is activated.

In this case, however, controller 320 also generates and sends a low battery code to identify that the alarm signal relates to a low battery condition. Controller 320 may also add a unique identification code that identifies
25 a particular controller 320 as the source of the low battery alarm signal. The institutional care giver who is monitoring the base station may use the identification code to immediately determine which apparatus 100 has a battery 380 with an unacceptably low level of voltage.

30 In an alternate embodiment of the present invention, controller 320 monitors the length of elapsed time between changes in inclination angles from tilt switch unit 300. When the elapsed time exceeds a preselected alarm period without receiving an inclination signal change, controller

320 enables the alarm signal with an identifying no-movement alarm indicator code. When the base station receives the no-movement alarm signal and alarm indicator code, the base station activates an audible alarm and a visual alarm that movement has been detected by controller 320 within the specified preselected alarm period. This feature may be used to alert a care giver that person 120 may be experiencing a problem. This feature may also be used to alert a care giver that apparatus 100 may not be properly attached to person 120 or may not be properly operating.

In another alternate embodiment of the present invention, controller 320 may tabulate the number of times that inclination signal transitions are received from tilt switch unit 300 during a preselected time interval. For example, controller 320 may monitor the number of inclination signal received within a four (4) hour period of time. Controller 320 then records the resulting ratio of "inclination signals" to "elapsed time" for periodic transfer to the base station. Care givers may use this data when analyzing patient recovery progress, degree of cognitive or physical decline, or other attributes that indicate the status of the patient.

In another embodiment of the present invention, controller 320 may continuously monitor and store the length of time associated with each transition period of the inclination signal from tilt switch unit 300. Controller 320 may save this information for a preselected period of time. For example, controller 320 may save the information for twenty four (24) hours. Upon request, controller 320 transmits this information (with appropriate identifier codes) to the base station for analysis.

FIGURE 4 shows an alternate embodiment of apparatus 100 in which radio frequency transmitter 340 and antenna

360 have been replaced with sound alarm unit 400 and speaker 420. In this embodiment of the invention, when controller 320 receives an inclination signal from tilt switch unit 300 indicating the occurrence of an excessively large inclination, controller 320 sends an alarm signal to sound alarm unit 400. Sound alarm unit 400 then causes audio speaker 420 to make a loud audible sound. A care giver within earshot of audio speaker 420 is thereby immediately alerted that person 120 has risen or is attempting to rise from bed 140 (or chair 200). As before, the care giver is then able to respond to person 120 and prevent person 120 from falling.

The audible alarm may also be used to remind the patient to wait for assistance from the care giver. Speaker 420 should be placed within the hearing of the patient and the care giver. In an alternate embodiment of the invention, controller 320 may provide signals for activating a proximate audible sound (such as a buzzer sound) to alert the patient to an alarm condition. The proximate audible sound may be given in addition to the previously described audible alarm signal given by speaker 420.

In another alternate embodiment of the invention, controller 320 comprises a voice synthesizer (not shown) that is connected through sound alarm unit 400 to speaker 420. When controller 320 detects an alarm condition, controller 320 activates a verbal message that is amplified through sound alarm unit 400 and announced by speaker 420. The verbal message may be used in place of the usual siren type of audio signal. This capability may be used to provide a verbal warning to the patient to wait for assistance from the care giver. Such a verbal warning would be more instructive and comforting to the patient than the usual siren type of audio signal.

In an alternate embodiment of the present invention (not shown) apparatus 100 comprises (1) a first circuit branch coupled to controller 320 where the first circuit branch comprises radio frequency transmitter 340 and antenna 360, and (2) a second circuit branch coupled to controller 320 where the second circuit branch comprises sound alarm unit 400 and speaker 420. This embodiment of the present invention combines the embodiment shown in FIGURE 3 and the embodiment shown in FIGURE 4.

FIGURE 5 is a schematic drawing of one embodiment of a tilt switch 500 that is capable of being used in the tilt switch unit 300 of the present invention. Tilt switch 500 comprises an enclosure 510 that completely encloses a metal ball 520 and two electrodes, 540 and 560. Electrode 540 is in the form of an elongated metal plate on which metal ball 520 may roll. The enclosure 510 of tilt switch 500 is preferably filled with an inert non-conductive viscous liquid. The viscosity of the liquid prevents metal ball 520 from accidentally rolling into contact with electrodes, 540 and 560. That is, metal ball 520 will not roll into contact with electrodes, 540 and 560, until person 120 and apparatus 100 has moved into a vertical position. The non-conductivity of the liquid prevents electrical contact between electrodes, 540 and 560, until they are both touched by metal ball 520.

When enclosure 510 is tilted toward the left in FIGURE 5, metal ball 520 rests on a portion of electrode 540 and makes no electrical contact with electrode 560. When enclosure 500 is tilted toward the right in FIGURE 5, metal ball 520 rolls along electrode 540 (though the inert non-conducting viscous liquid) and comes into contact with electrode 560. This causes electrical contact between electrode 540 and electrode 560 though electrically conducting metal ball 520. This causes an electrical path

to form through electrode 540, metal ball 520 and electrode 560, thereby closing tilt switch 500. Tilt switch 500 closes when tilt switch 500 has been tilted by at least seventy degrees (70°).

5 FIGURE 6 is a schematic drawing of an alternate embodiment of a tilt switch 600 that is capable of being used in the tilt switch unit 300 of the present invention. Tilt switch 600 comprises an enclosure 610 that completely encloses a ball 620 of liquid mercury and two electrodes,
10 640 and 660. Mercury is a liquid metal at room temperature and forms into a ball due to surface tension. In an advantageous embodiment of the present invention, enclosure 610 is made of glass. It is clear, however, that other electrically non-conducting materials can be used to
15 construct enclosure 610.

Electrode 640 and electrode 660 are aligned in parallel at one end of enclosure 600. Electrode 640 is longer than electrode 660 as shown in FIGURE 6. When enclosure 610 is tilted toward the left in FIGURE 6, liquid
20 mercury ball 620 rests on the end of enclosure 600 opposite from the end of enclosure 610 that contains electrodes, 640 and 660, and there is no electrical contact between electrodes, 640 and 660.

When enclosure 610 is tilted toward the right in
25 FIGURE 5, liquid mercury ball 620 slides into contact with electrode 640. When the angle of tilt toward the right becomes sufficiently great, the weight of the mercury in liquid mercury ball 620 exceeds the surface tension of liquid mercury ball 620. Then the mercury in liquid
30 mercury ball 620 ceases to take the form of a ball and flows into contact with electrodes, 640 and 660. The existence of a continuous mercury path between electrode 640 and electrode 660 causes electrical contact between electrode 640 and electrode 660 though the electrically

conducting liquid mercury. Tilt switch 600 is then in a closed condition. Tilt switch 600 closes when tilt switch 600 has been tilted by at least seventy degrees (70°).

FIGURE 7a is a schematic drawing of tilt switch unit 300 of an advantageous embodiment of the present invention showing a first tilt switch 500 in series with a second tilt switch 600. In the position of tilt switch unit 300 shown in FIGURE 7a the person 120 is lying on his or her back. There is no alarm signal because the tilt switches 500 and 600 are not closed.

When the person 120 is lying on his or her right side the position of tilt switch unit 300 is shown in FIGURE 7b. There is no alarm signal because only one of the switches is closed. Both tilt switch 500 and tilt switch 600 must be closed for the alarm to sound. Similarly, when the person 120 is lying on his or her left side the position of tilt switch unit 300 is shown in FIGURE 7c. As before, there is no alarm signal because only one of the switches is closed and both tilt switch 500 and tilt switch 600 must be closed for the alarm to sound.

When the person 120 is in a prone position (i.e., lying on his or her stomach) the position of tilt switch unit 300 is shown in FIGURE 7d. There is an alarm signal because both of the switches 500 and 600 are closed.

This feature may be used in an apparatus for monitoring the body orientation of a person to signal a care giver when a person has turned over on his or her stomach. This feature is especially suited to prevent death arising from sudden infant death syndrome in small children or infants who are sleeping. The safest sleeping position for small children or infants is the position where the child or infants sleeps on his or her back. The most dangerous sleeping position for small children or

infants is the position where the child or infants sleeps on his or her stomach.

FIGURE 8 is a schematic drawing of tilt switch unit 300 of an advantageous embodiment of the present invention showing a first tilt switch 500 in parallel connection with a second tilt switch 600 and in parallel connection with a third tilt switch 700. In this advantageous embodiment of the present invention, tilt switch 500 is aligned parallel to the x-axis of a three dimensional Cartesian co-ordinate system. Tilt switch 600 is aligned parallel to the y-axis and tilt switch 700 is aligned parallel to the z-axis. Controller 320 is coupled to each of the three tilt switches 500, 600 and 700. Controller 320 is capable of simultaneously determining which tilt switch (of the three tilt switches) is open and which tilt switch (of the three tilt switches) is closed. In this manner, controller 320 can determine any combination of open tilt switches and closed tilt switches in tilt switch unit 300.

Although the three tilt switches 500, 600 and 700 are shown in FIGURE 8 at right angles to each other, this arrangement is illustrative only. Other angles may be chosen for orienting the three tilt switches 500, 600 and 700.

Although each of the three tilt switches 500, 600 and 700 are shown in FIGURE 8 as single tilt switches, this arrangement is illustrative only. Each tilt switch 500, 600 and 700 may be replaced with two or more additional tilt switches (not shown). In other words, additional tilt switches (not shown) may be used in addition to tilt switches 500, 600 and 700, shown in FIGURE 8. The additional tilt switches may be oriented in any chosen direction and are not limited to being in the same plane as one of the tilt switches 500, 600 and 700 (or in the same plane as one of the additional tilt switches). In general,

the tilt switches of tilt switch unit 300 may be coupled in series, or in parallel, or in a combination of series and parallel connections.

Controller 320 is a programmable controller that is capable of being programmed to sound an alarm condition only when controller 320 receives a signal from a predetermined combination of closed (or open) tilt switches in accordance with pre-programmed instructions in controller 320. In this manner, controller 320 can identify when the body to which tilt switch unit 300 is coupled has an inclination that matches a specified orientation.

FIGURE 9 is a detailed circuit diagram showing the interconnection of tilt switch 500 and tilt switch 600 in series and the interconnection of controller 320. One end of tilt switch 500 (referred to in FIGURE 9 as "S1") is connected to input pin 12 (labeled "P2.4") of controller 320. The other end of tilt switch 500 is connected to one end of tilt switch 600 (referred to in FIGURE 9 as "S2"). The other end of tilt switch 600 is connected to battery 380 (shown in FIGURE 9 as a three volt (+3V) power supply). When both tilt switch 500 and tilt switch 600 become closed due to the tilt of apparatus 100, the circuit branch containing tilt switches 500 and 600 generates an interrupt signal to controller 320. Controller 320 interprets the interrupt signal as an alarm inclination signal indicating that, for example, tilt switch unit 300 has the orientation shown in FIGURE 7d indicating that a sleeping child has rolled over on its stomach.

FIGURE 10 is a detailed circuit diagram of one embodiment of 340 transmitter and antenna 360 that can be used with apparatus 100 of the present invention. The transmitter 340 is of a conventional type and is designed

to transmit a radio signal at a radio frequency of four hundred eighteen megaHertz (418 MHz).

FIGURE 11 is a flow diagram describing the logic of the operation of an advantageous embodiment of the present invention. The operation steps of the method of the present invention are collectively referred to in FIGURE 11 as operation steps 1100. The first operation step 1110 comprises preselecting an inclination angle in tilt switch unit 300 that will indicate a specified orientation. The inclination angle in one advantageous embodiment of the present invention is selected to be seventy degrees (70°).

The second operation step 1120 comprises attaching the tilt switch unit 300 to a body. Although the body is usually the body of a person 120, the body could be any animate or inanimate body. The third operation step 1130 comprises determining when the body has moved so that tilt switch unit 300 has become oriented in the specified orientation. In the previously mentioned advantageous embodiment of the present invention, a determination is made that the body has moved so that the inclination angle of tilt switch unit 300 exceeds seventy degrees (70°).

The fourth operation step 1140 comprises generating an alarm signal that indicates that the tilt switch unit 300 is aligned in the specified orientation. In the previously mentioned advantageous embodiment of the present invention, an alarm signal is generated that indicates that the inclination angle of tilt switch unit 300 exceeds seventy degrees (70°).

Although the present invention has been described in detail, those skilled in the art should understand that they can make various changes, substitutions and alterations herein without departing from the spirit and scope of the invention in its broadest form.

WHAT IS CLAIMED IS:

1. An apparatus for detecting an inclination of a body to which said apparatus is attached comprising:

5 at least two tilt switches capable of determining when said apparatus has been inclined in an amount greater than a preselected inclination angle, and in response to said determination, generating an inclination signal; and

10 a controller coupled to said at least two tilt switches capable of detecting said inclination signal from said at least two tilt switches, and in response to said detection, generating an alarm signal.

2. An apparatus as claimed in Claim 1 further comprising a signaling device coupled to said controller capable of receiving said alarm signal, and in response to receipt of said alarm signal, one of: (a) generating an audible alert and (b) wirelessly transmitting an alert message to a remote monitoring device.

20 3. An apparatus as claimed in Claim 2 wherein said alarm signaling device is a radio frequency transmitter that transmits a radio frequency signal that is capable of being received by a base station radio receiver.

25 4. An apparatus as claimed in Claim 2 wherein said alarm signaling device is an audio speaker that transmits an audible sound signal.

30 5. The apparatus as claimed in Claim 1 wherein each of said at least two tilt switches comprises an enclosure containing a metal ball and two electrodes, wherein said metal ball makes electrical contact with said two

electrodes when said enclosure is tilted to cause said metal ball to contact said two electrodes.

5 6. The apparatus as claimed in Claim 1 wherein each of said at least two tilt switches comprises an enclosure containing liquid mercury metal and two electrodes, where said liquid mercury metal makes electrical contact with said two electrodes when said enclosure is tilted to cause said liquid mercury metal to contact said two electrodes.

10 7. An apparatus as claimed in Claim 5 wherein said alarm signaling device is a radio frequency transmitter that transmits a radio frequency signal that is capable of being received by a base station radio receiver.

15 8. An apparatus as claimed in Claim 6 wherein said alarm signaling device is a radio frequency transmitter that transmits a radio frequency signal that is capable of being received by a base station radio receiver.

20 9. An apparatus as claimed in Claim 1 wherein said controller receives said inclination signal for length of time that exceeds a preselected length of time before said controller generates said alarm signal.

25 10. An apparatus as claimed in Claim 9 wherein said preselected length of time is at least two seconds.

30 11. An apparatus as claimed in Claim 3 wherein said controller generates an identification code for transmission by said radio frequency transmitter.

12. An apparatus as claimed in Claim 3 wherein said controller generates a code that indicates a low battery condition for transmission by said radio frequency transmitter.

5

13. An apparatus as claimed in Claim 1 wherein said controller is capable of determining the length of elapsed time between the detection of a first inclination angle and the detection of a second inclination angle, and wherein said controller is capable of comparing said elapsed time with a preselected length of time to determine when said elapsed time has exceeded said preselected length of time, and wherein said controller, in response to said detection, is capable of generating an alarm signal.

10

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14. An apparatus as claimed in Claim 13 further comprising a signaling device coupled to said controller capable of receiving said alarm signal, and in response to receipt of said alarm signal, one of: (a) generating an audible alert and (b) wirelessly transmitting an alert message to a remote monitoring device.

20

15. A method for determining when a person is standing up, comprising the steps of:

preselecting an inclination angle within at least two tilt switches attached to the person so that when one of said at least two tilt switches is rotated to a position having an angle that is greater than said preselected inclination angle said one of said at least two tilt switches is approximately vertical with respect to a horizontal reference; and

determining when said one of said of least two tilt switches attached to the person has been rotated to a position having an angle that is greater than said preselected inclination angle.

16. A method for alerting a care giver when a person is standing up, comprising the steps of:

preselecting an inclination angle within at least two tilt switches attached to the person so that when one of said at least two tilt switches is rotated to a position having an angle that is greater than said preselected inclination angle said one of said at least two tilt switches is approximately vertical with respect to a horizontal reference;

determining when said one of said at least two tilt switches attached to the person has been rotated to a position having an angle that is greater than said preselected inclination angle; and

generating an alarm signal in response to said determination to alert the care giver that the person is standing up.

17. A method as claimed in Claim 16 further comprising the step of:

generating an audible alert in response to said alarm signal.

5

18. A method as claimed in Claim 17 wherein the step of generating an audible alert comprises the step of transmitting an audible sound signal through an audio speaker.

10

19. A method as claimed in Claim 16 further comprising the step of:

generating a wireless transmission of an alert message to a remote monitoring device in response to said alarm signal.

15

20. A method as claimed in Claim 19 where the step of generating a wireless transmission comprises the step of generating a radio frequency transmission with a radio frequency transmitter.

20

21. A method for alerting a care giver when one person of a plurality of persons is standing up, comprising the steps of:

5 attaching at least two tilt switches to each of said plurality of persons;

10 preselecting an inclination angle within each of said at least two tilt switches attached to each of said plurality of persons so that when one of each of said at least two tilt switches is rotated to a position having an angle that is greater than said preselected inclination angle, then each one of said at least two tilt switches so rotated is approximately vertical with respect to a horizontal reference;

15 determining when one of said at least two tilt switches attached to one person of said plurality of persons has been rotated to a position having an angle that is greater than said preselected inclination angle; and

20 generating a signal in response to said determination to alert the care giver that said one person of said plurality of persons is standing up.

22. A method for alerting a care giver of a low level of battery power in one battery of a plurality of batteries that are attached to a plurality of tilt switches that are attached to a plurality of persons, comprising the steps of:

attaching a plurality of batteries to said plurality of tilt switches, with each battery of said plurality of batteries attached to one of said plurality of tilt switches;

determining when one battery of said plurality of batteries attached to said plurality of tilt switches has a low level of battery power; and

generating a signal in response to said determination to alert the care giver that said one battery of said plurality of batteries has a low level of battery power.

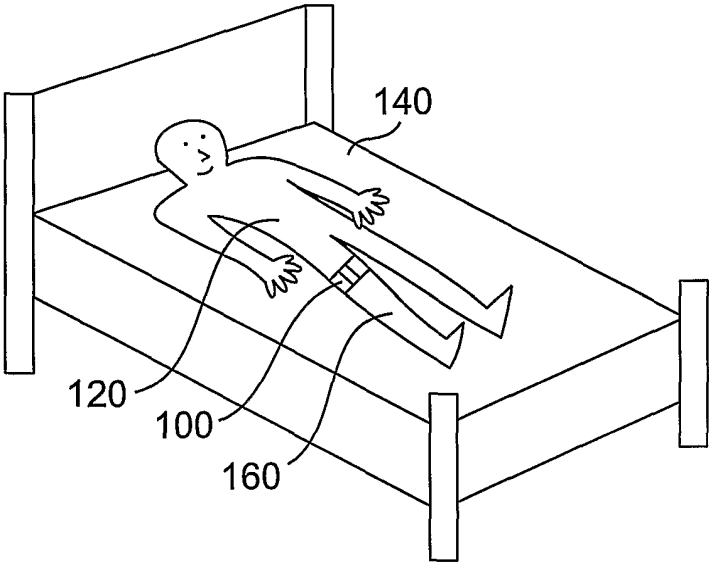


FIG. 1

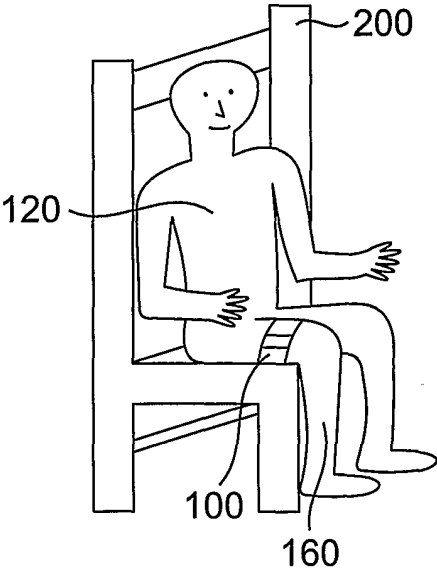


FIG. 2

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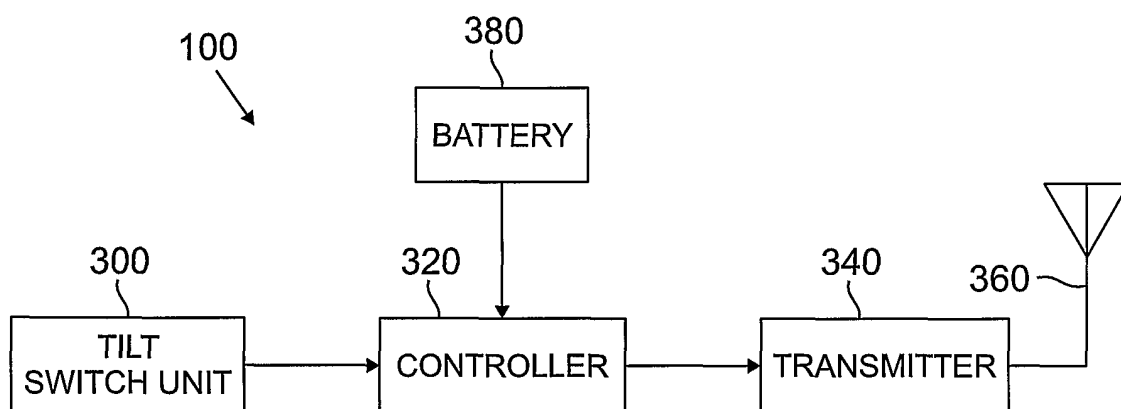


FIG. 3

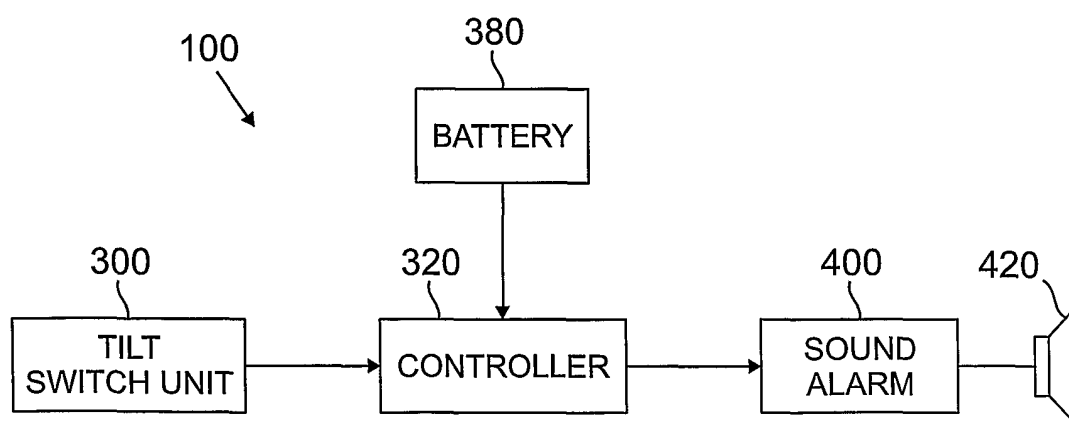


FIG. 4

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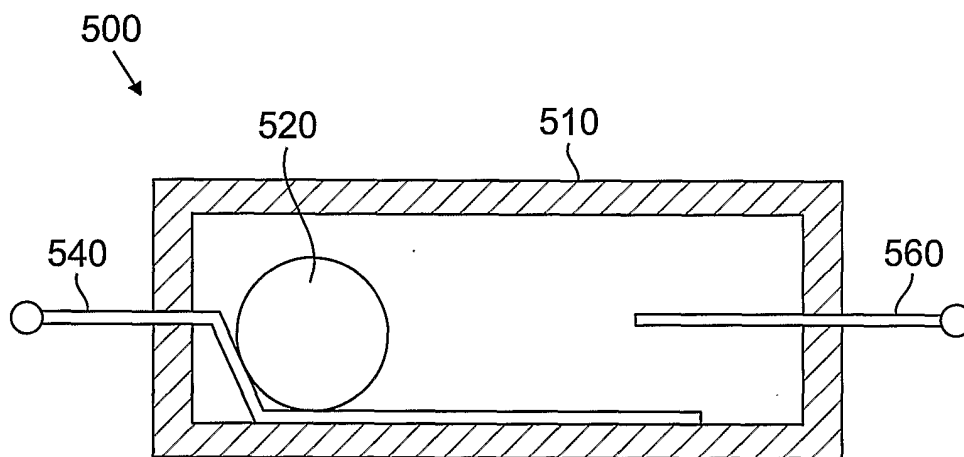


FIG. 5

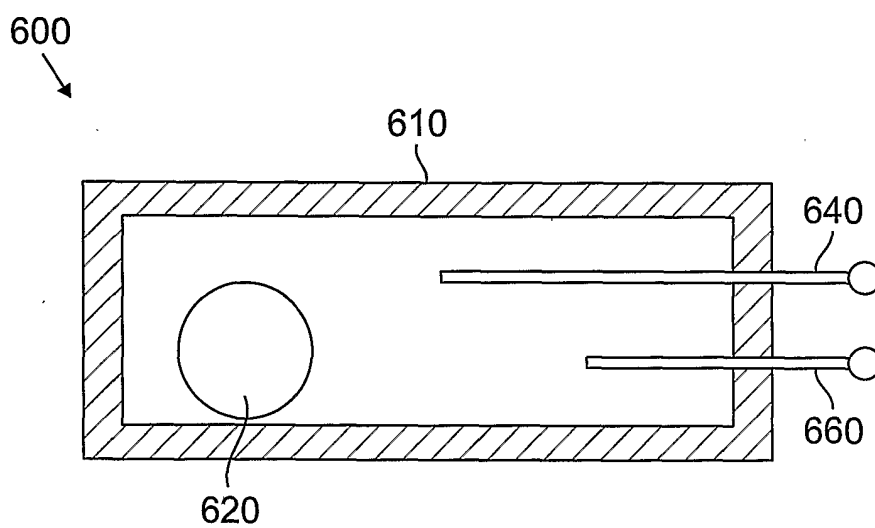


FIG. 6

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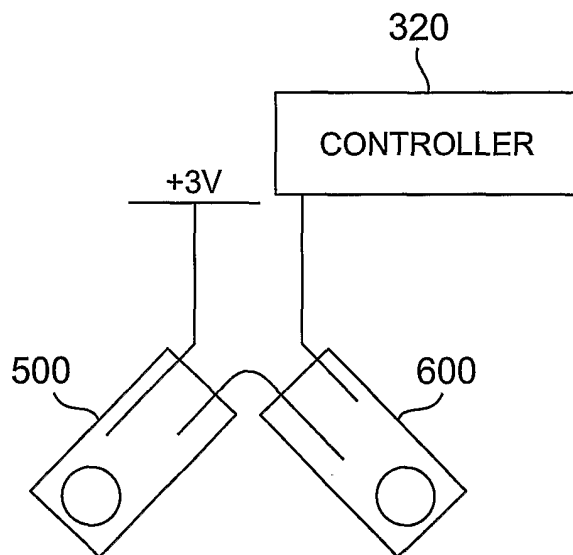


FIG. 7a

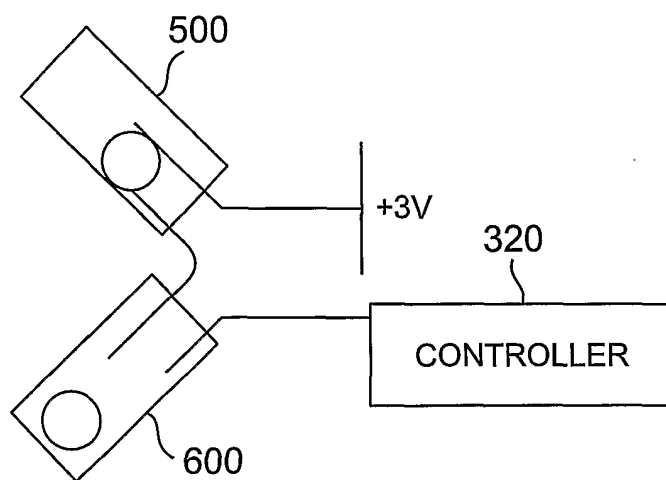
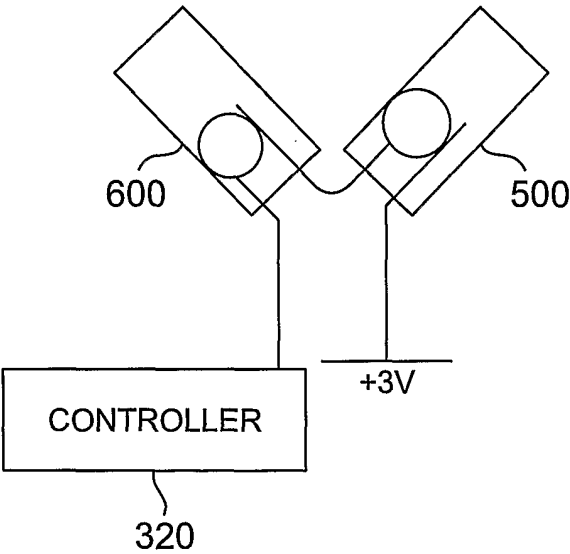
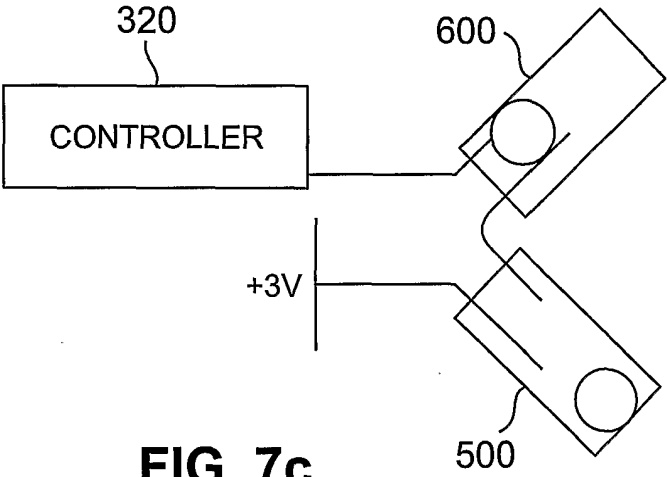


FIG. 7b



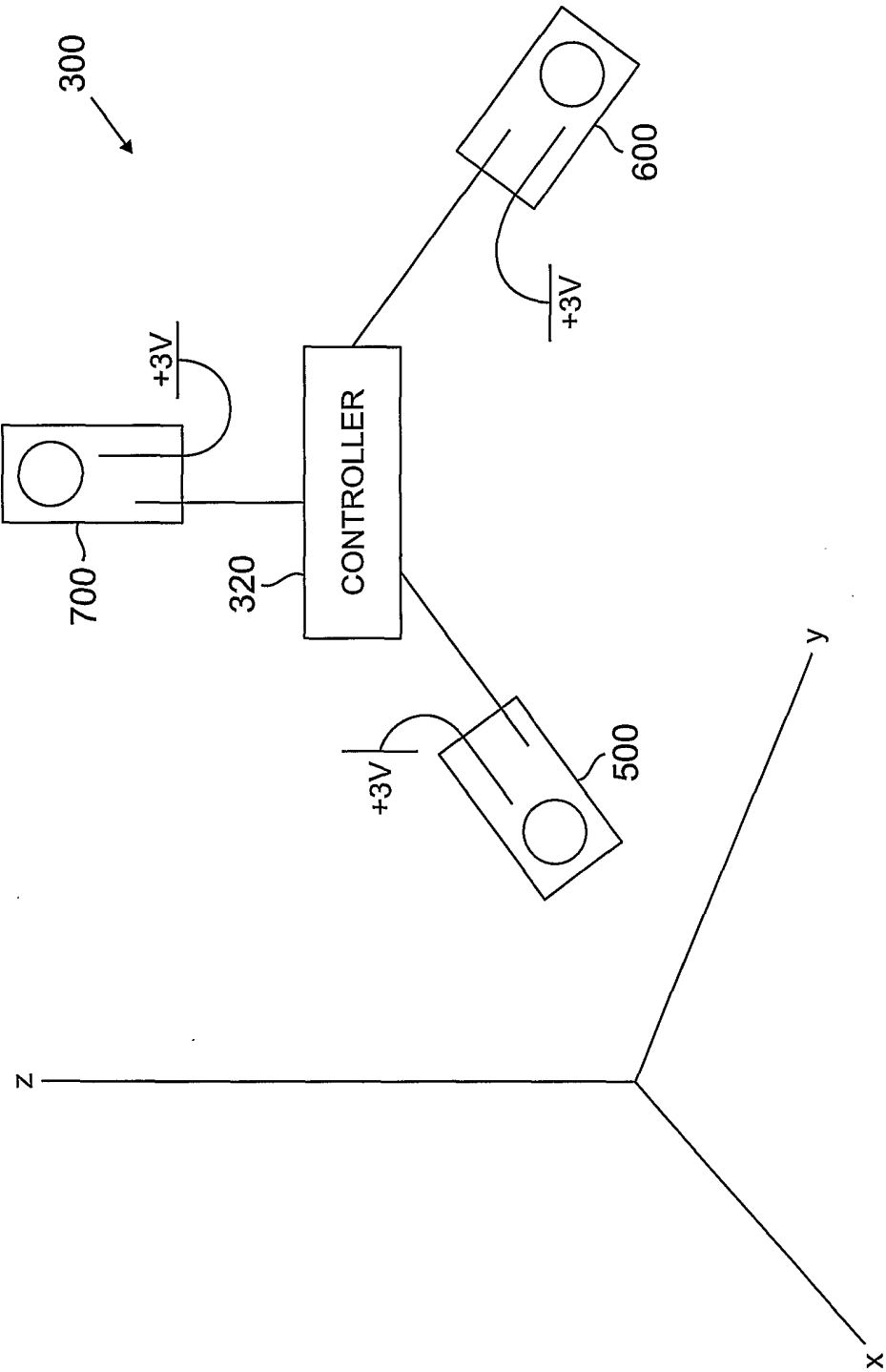


FIG. 8

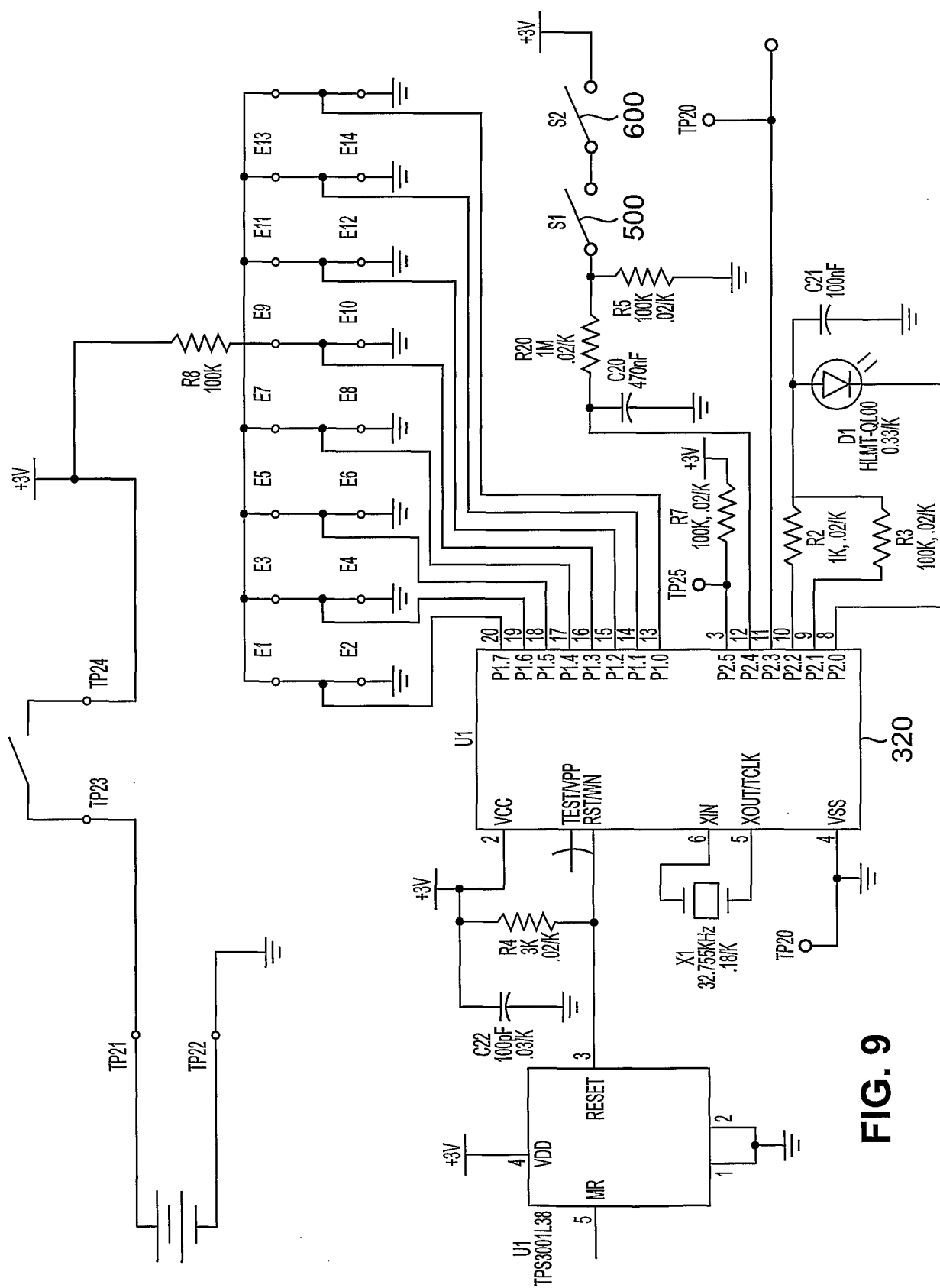


FIG. 9

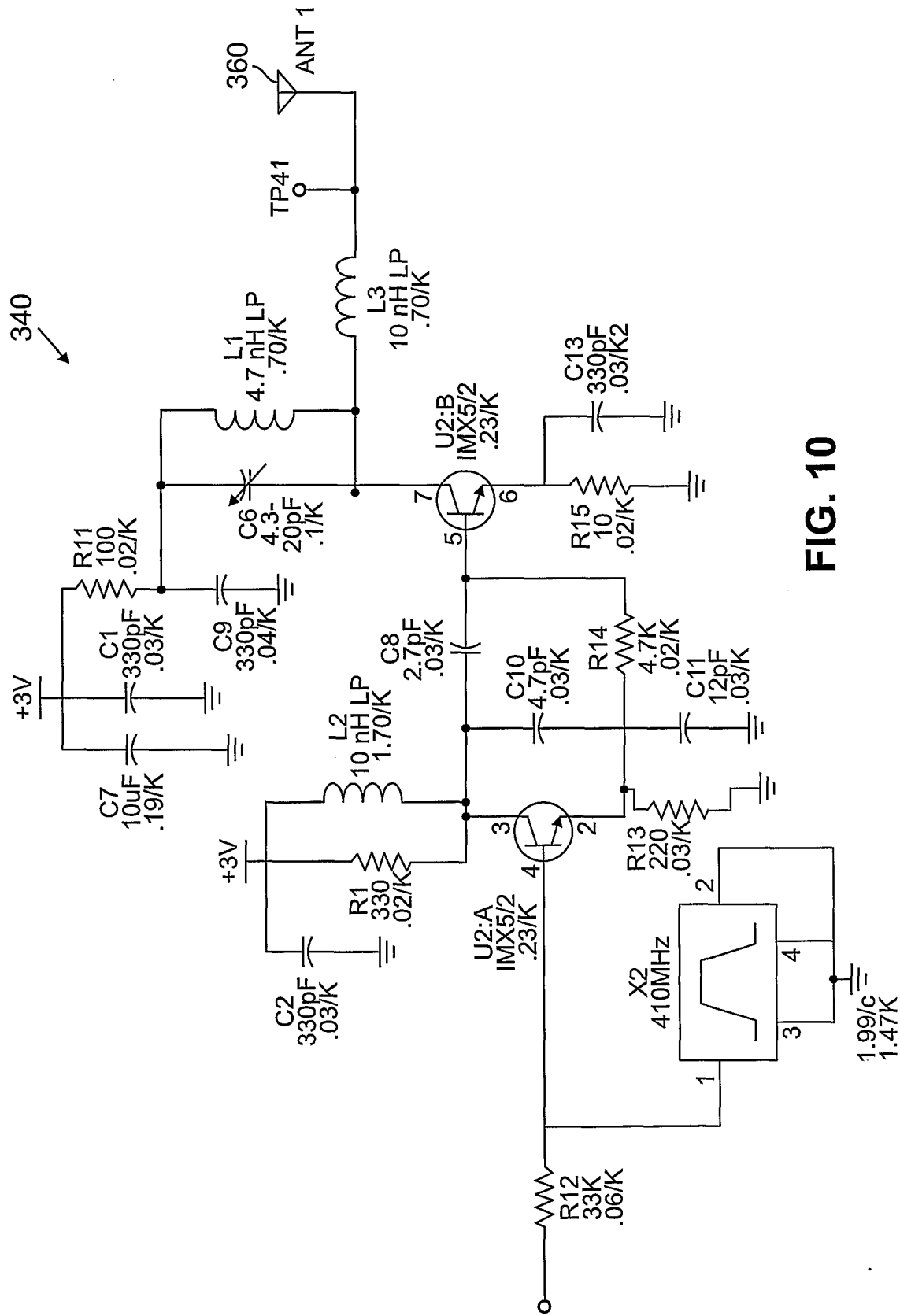


FIG. 10

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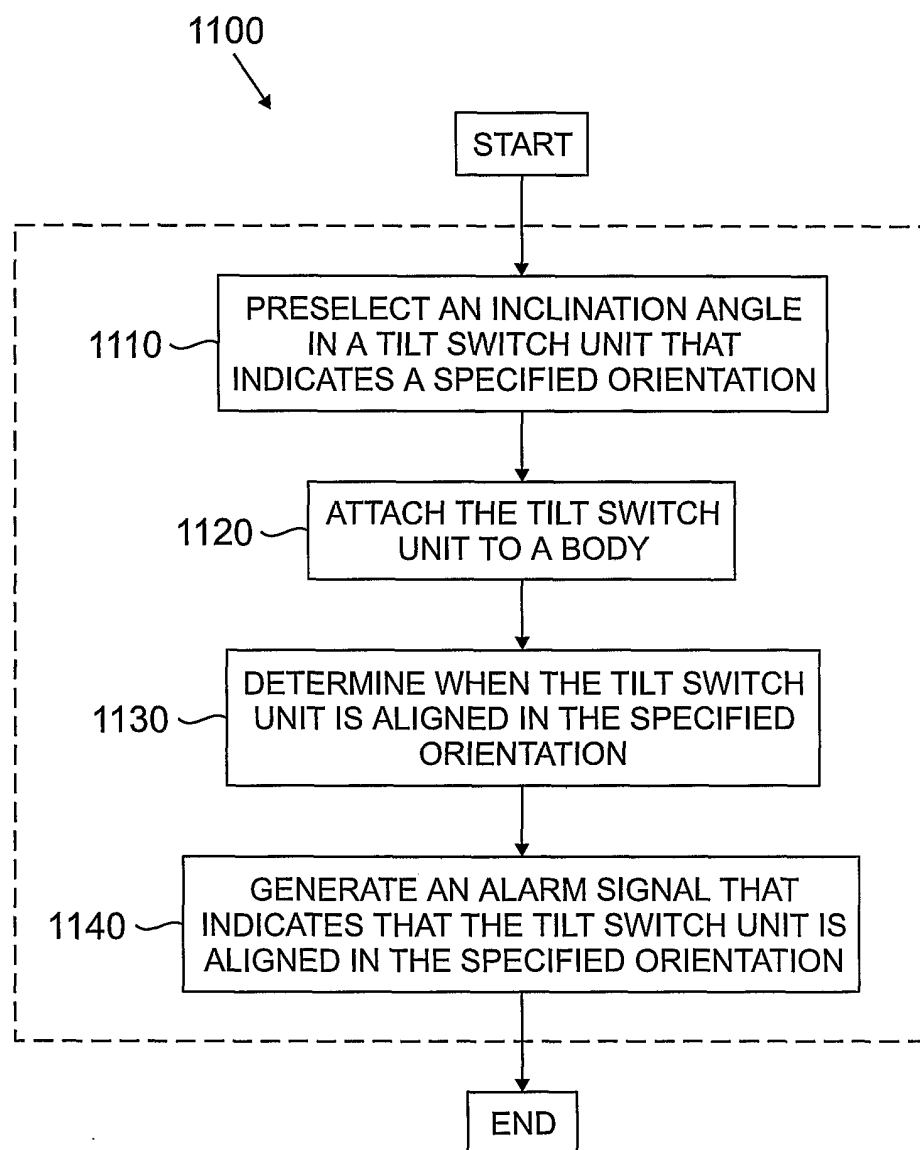


FIG. 11

INTERNATIONAL SEARCH REPORT

 International application No.
PCT/US01/09391

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G08B 21/00

US CL : Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 340/689, 686.1, 687, 573.1; 200/5R, 61.45R, 61.46, 61.52, 81.9HG, 83T, 239, 240

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONEElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- Y	US 5,038,137 A (LLOYD) 06 August 1991, col. 3, lines 44-68; col. 4, lines 1-4, 21-58; col. 7, lines 36-42 Figs. 2a-2e, 4.	1, 2, 4, 6, 9, 10, 13, 14, 16-19 ----- 3, 5, 7, 8, 11, 12, 20, 22
Y	US 4,972,177 A (NOLAN) 20 November 1990, col. 4, lines 34-41; Fig. 6.	3, 7, 8, 11, 20
Y	US 4,617,525 A (LLOYD) 14 October 1986, col. 5, lines 26-34; Fig. 5.	5
Y	US 5,554,975 A (HALL et al.) 10 September 1996, col. 4, lines 10-13.	12 and 22



Further documents are listed in the continuation of Box C.



See patent family annex.

"A"	document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier document published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

18 MAY 2001

Date of mailing of the international search report

18 JUN 2001

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/09391

A. CLASSIFICATION OF SUBJECT MATTER:

US CL :

340/689, 686.1, 687, 573.1; 200/5R, 61.45R, 61.46, 61.52, 81.9HG, 83T, 239, 240