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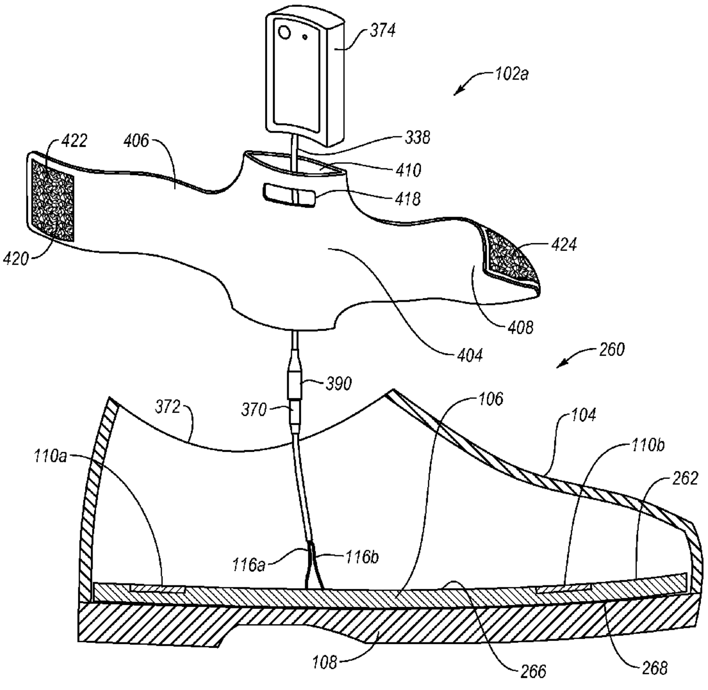

Fig. 16

(57) Abstract: Systems and methods of monitoring a running step and signaling the runner when a correction is desired. In one aspect, the portion of the foot that contacts the ground first is monitored to determine if a correction is desired. To monitor the running step, a step analyzing apparatus can be used that is positioned within a shoe. The step analyzing apparatus can include sensors that are positioned at the midfoot and the heel when the apparatus is within the shoe. To signal the runner, an indicator can be used that is positioned within the shoe or outside the shoe. The step analyzing apparatus can also be used in a ski boot to monitor proper ski form. Running cadence can also be monitored to determine if a correction is desired.

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SYSTEM FOR MONITORING RUNNING STEPS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to US Application No. 13/346,546, filed January 9, 2012 which application is incorporated herein by specific reference.

BACKGROUND OF THE INVENTION

1. The Field of the Invention

[0002] The present application generally relates to devices and methods for athletic training. More specifically, the present application relates to devices and methods for optimizing foot action during running.

2. The Relevant Technology

[0003] In recent years many individuals have turned to their own fitness program of regular jogging. Jogging has long been recognized for its therapeutic effects on the body. It purportedly increases cardiopulmonary fitness, helps to lower blood pressure, decreases cholesterol and triglyercides associated with heart disease and reduces weight. Jogging is also one of the easiest exercises to do. It requires no athletic ability and can be done almost any time and any place with a minimum of equipment and without assistance.

[0004] The popularity of jogging today is well documented by the large numbers of products and literature available to the public. As in many exercise and sporting endeavors, there exists in the prior art a wide variety of devices for aiding those who jog. Many people who jog desire to know their progress over time. For example, many joggers and runners want to know the accurate distance and speed traveled during an exercise session. This information allows a jogger to monitor his or her progress and accordingly pursue a regular course of exercise designed to enhance performance. Conventional systems record the number of steps the jogger takes and provides the jogger with rate and distance information for their period of travel.

[0005] In more recent times, many joggers have begun running competitively. As with recreational joggers, competitive runners also desire to know their progress over time. One area that can increase performance and lower running times is improvement in a runners step and stride. The step refers to how the foot contacts and leaves the ground, while the stride refers to the distance and time between steps. While many devices exist for measuring a runner's stride, few devices exist that give information on a runner's step. Yet the manner in which the foot contacts and leaves the ground can greatly affect a runner's performance. For example, according to various experts, for optimal running efficiency and performance, the midfoot of the foot should be the first part of the foot that contacts the ground.

[0006] Therefore, it would be an improvement in the art to provide systems and methods for monitoring a running step to help optimize the running step.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Various embodiments of the present invention will now be discussed with reference to the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. In the drawings, like numerals designate like elements. Furthermore, multiple instances of an element may each include separate letters appended to the element number. For example two instances of a particular element "20" may be labeled as "20a" and "20b". In that case, the element label may be used without an appended letter (e.g., "20") to generally refer to every instance of the element; while the element label will include an appended letter (e.g., "20a") to refer to a specific instance of the element.

[0008] Figure 1 is an exploded side view of a system for monitoring running steps according to one embodiment;

[0009] Figure 2 is a schematic representation of the step analyzing apparatus shown in Figure 1;

[0010] Figure 3 is a schematic representation of a portion of a step analyzing apparatus according to another embodiment, showing an indicator that is wirelessly coupled to the processor via a transmitter and receiver;

[0011] Figure 4 is a block diagram of a method of monitoring running steps according to one embodiment;

[0012] Figure 5 is a block diagram of a method of monitoring running steps according to another embodiment;

[0013] Figure 6 is a block diagram of a method of monitoring running steps according to another embodiment;

[0014] Figure 7 is a top schematic view of an insole with a step analyzing apparatus mounted thereon, according to one embodiment;

[0015] Figure 8 is a cross sectional side view of the insole shown in Figure 7 positioned within a shoe;

[0016] Figure 9 is a cross sectional side view of a sock with a step analyzing apparatus mounted thereto;

[0017] Figure 10 is a partially exploded cross sectional side view of a system for monitoring running steps incorporated into the sole of a shoe;

[0018] Figure 11 illustrates a step analyzing apparatus positioned within a ski boot according to one embodiment;

[0019] Figure 12 is a block diagram of a method of monitoring cadence of a runner according to one embodiment;

[0020] Figure 13 is a block diagram of a method of monitoring cadence of a runner according to another embodiment;

[0021] Figure 14 is a block diagram of a method of monitoring cadence of a runner according to another embodiment;

[0022] Figure 15 is a top schematic view of a cadence analyzing apparatus according to one embodiment;

[0023] Figure 16 is a partially exploded side view of an alternative embodiment of a system for monitoring running steps wherein the system includes a controller that is remote from an insole housing the sensors;

[0024] Figure 17 is a partially exploded perspective view of the controller shown in Figure 16;

[0025] Figure 18 is an elevated side view of the back side of the circuit board shown in Figure 17;

[0026] Figure 19 is a block diagram of a method of calibrating the sensors of the step analyzing apparatus; and

[0027] Figure 20 is a block diagram of an alternative method of using the step analyzing apparatus to determine whether the heel or midfoot is first landing in a running step.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0028] As used in the specification and appended claims, directional terms, such as "top," "bottom," "up," "down," "upper," "lower," "proximal," "distal," and the like are used herein solely to indicate relative directions and are not otherwise intended to limit the scope of the invention or claims.

[0029] The term "shoe", as used herein, refers to any type of external covering for the human foot. For example, the term "shoe" can include any type of foot covering typically referred to in the art as a shoe, as well as slippers, boots, flip-flops, sandals, moccasins, and the like. The term "runner", as used herein, can refer to anyone who engages in the act of running. As such, the term "runner" encompasses professional runners who run competitively, joggers who run recreationally, and everyone in between. The term "runner" also encompasses those for whom running is not their primary focus. For example, any athlete who runs in the course of training or competing are encompassed by the term "runner" herein. By way of example and not limitation, this can include those involved in basketball, tennis, soccer, volleyball, football, and the like.

[0030] The present invention relates to systems and methods of monitoring a running step and signaling the runner when a correction is warranted. In one embodiment, the portion of the foot that contacts the ground first is monitored to determine if a correction is warranted. To do so, a step analyzing apparatus can be used that is positioned within or incorporated into a shoe. The step analyzing apparatus can include sensors that are positioned at the midfoot and the heel when the apparatus is within the shoe. To signal the runner, an indicator can be used that is positioned within the shoe or outside the shoe. In another embodiment, the step analyzing apparatus can be used in a ski boot to monitor proper ski form. In one embodiment, running cadence can be monitored to determine if a correction is warranted.

[0031] Figure 1 is an exploded side view of a system 100 for monitoring running steps according to one embodiment. System 100 includes a step analyzing apparatus 102 that is positionable within a shoe 104 so as to be at least partially disposed under the foot of the shoe wearer. In the depicted embodiment, step analyzing apparatus 102 is positionable under an insole 106 of the shoe. That is, analyzing apparatus 102 is positionable between insole

106 and sole 108 of shoe 104. Insole 106 can be any insole known in the art, or one that is specifically designed for use with step analyzing apparatus 102. If desired, insole 106 can comprise the insole that is sold with the shoe, although this is not required. In the depicted embodiment, step analyzing apparatus 102 is removable from shoe 104. In other embodiments, step analyzing apparatus 102 can be secured to or incorporated into sole 108 or insole 106 of shoe 104. For example, the components of step analyzing apparatus 102 can be secured to sole 108 and/or insole 106 using an adhesive, fasteners, or the like or by being embedded therein.

[0032] Figure 2 is a schematic representation of step analyzing apparatus 102. Step analyzing apparatus 102 comprises one or more sensors 110, each configured to measure or detect foot force or pressure thereon. For example, the depicted embodiment includes a first sensor 110a and a second sensor 110b. Of course, more than two sensors can be incorporated into step analyzing apparatus 102 if desired. During use, sensors 110 are positioned under different portions of a runner's foot to detect when the portion of the shoe associated with the particular portion of the foot contacts a running surface, such as concrete, asphalt, grass, or the like, as discussed in more detail below. Sensors 110 can be positioned under any portion of the foot desired. In one embodiment, first sensor 110a and second sensor 110b are respectively positioned within shoe 104 (Figure 1) so as to be under the heel and midfoot of the runner's foot, respectively. The midfoot is commonly referred to as the forefoot and includes but is not limited to the area under the five metatarsal bones. As such, second sensor 110b can be located below one or more of the metatarsal bones including the 5^{th} metatarsal bone. The sensors can also be sized so that they extend beyond being located just under the heel and midfoot.

[0033] In some embodiments, sensor 110 can detect when a force or pressure greater than or equal to a predetermined amount is generated thereagainst. The predetermined amount can vary, depending on the shoe type, the runner type, the runner's weight and build, and other factors. For example, sensor 110 can comprise a switch that switches "on" when a force or pressure greater than or equal to a predetermined amount is generated thereagainst, such as a force switch, a pressure switch, or a gravity switch, as is known in the art. Other switches or similar force detection devices, as are presently known in the art or may become known in the art in the future, can also be used.

[0034] In some embodiments, sensor 110 can reflect the amount of force or pressure generated thereagainst. For example, sensor 110 can comprise a tactile sensor that senses the amount of force or pressure generated thereagainst, such as a transducer, a force sensor, a pressure sensor, or a strain gauge, as is known in the art. Other tactile sensors or similar force detection devices, as are presently known in the art or may become known in the art in the future, can also be used.

[0035] One example of a force sensor that can be used is the FLEXIFORCE force sensor which is available from Tekscan, Inc. The FLEXIFORCE force sensor is a flexible, printed circuit, piezoresistive force and load sensor. Another sensor that can be used is an air bladder pressure sensor. This sensor comprises a thin bladder having a small quantity of air sealed therein. A pressure sensor is attached to the bladder. As a load is applied to the bladder, the bladder expands. In turn, the expansion is detected by the pressure sensor and used to measure the applied load. It is again appreciated that a variety of different sensors can be used.

[0036] First and second sensors 110a and 110b can both comprise the same type of sensor or can comprise different types of sensors. Regardless of the type of sensor used, each sensor 110 can have an output port 114 for transmitting a signal indicating the status of the sensor. For example, for switch type sensors, the transmitted signal can indicate the presence or absence of the predetermined amount of force, and for tactile type sensors, the transmitted signal can be indicative of the amount of force or pressure exerted against the sensor. In the depicted embodiment the signals are transmitted by output ports 114 over one or more wires 116. In other embodiments one or more of the signals can be transmitted wirelessly.

[0037] Step analyzing apparatus 102 can further comprise an indicator 118 for signaling the runner when certain conditions occur. For example, in one embodiment, indicator 118 can be used to signal the user when it is determined that one or more incorrect steps have occurred. In some embodiments, indicator 118 can be used to signal the user when a predetermined number of correct steps have occurred. Indicator 118 can also be used at other times, if desired, to signal the runner.

[0038] Indicator 118 can comprise any type of signaling device that can provide notice to the runner when activated. For example, in one embodiment, indicator 118 can comprise a vibrator, such as a vibrator used in a cellular telephone, that vibrates when activated to provide notice to the runner. Other types of signaling devices can also be used. By way of example and not limitation, besides a vibrator, indicator 118 can comprise an audio device, (e.g. a speaker), a visual display device (e.g., a light, one or more LEDs, or a display screen such as can be hand held, incorporated onto a wrist band, or mounted or formed on a separate structure, such as a treadmill) or any other signaling device that can provide notice to the runner. In some embodiments, more than one type of signaling device can be used.

[0039] Depending on the type of signaling device used, indicator 118 can be positioned within the shoe or external to the shoe. For example, when a vibrator is used as indicator 118, the vibrator can be positioned on or under the foot, such as under or adjacent to the arch of the foot, similar to the rest of step analyzing apparatus 102, where the runner will feel the vibration when the vibrator is activated. When an audio or visual display device is used as indicator 118, the device can be positioned on the exterior surface of the shoe or can be positioned at a location remote to the shoe, where the runner is more likely to notice the signal. For example, the audio device could be positioned at or near the ears of the runner, while the visual display device could be positioned on the wrist of the runner or another location where the visual display device would be noticed by the runner, such as, e.g., on the display of a treadmill during indoor workouts. The indicator can also be positioned at other locations.

[0040] Indicator 118 includes an activating input port 120 used to activate indicator 118. When an activating signal is received on activating input port 120, indicator 118 can signal the runner. In some embodiments, indicator 118 is always powered on and is activated to signal the runner using a separate control line. In other embodiments, indicator 118 is configured to always be activated whenever power is applied to it. In those embodiments, activating input port 120 can simply comprise providing power to indicator 118.

[0041] In the depicted embodiment the signals are received by activating input port 120 over one or more wires 122. In other embodiments, such as when indicator 118 is positioned outside of the shoe, one or more of the signals can be transmitted wirelessly.

[0042] Step analyzing apparatus 102 can also comprise a processor 124 in electrical communication with sensors 110 and indicator 118 so as to receive and analyze the signals transmitted by sensors 110 and activate indicator 118 when desired. Processor 124 can have one or more input ports 126 coupled with wires 116 for receiving the signals transmitted by sensors 110. In the depicted embodiment, input ports 126a and 126b respectively receive the signals transmitted by output ports 114a and 114b of sensors 110a and 110b over wires 116a and 116b. For those embodiments in which a signal is transmitted wirelessly by sensor 110, input ports 126 can be configured to receive the corresponding signal(s) wirelessly.

[0043] Similarly, processor 124 can have one or more output ports 128 coupled with wires 122 for transmitting activating signals to indicators 118. For example, in the depicted embodiment, a single output port 128 is used to transmit an activating signal over wires 122 to activating input port 120 of indicator 118. For those embodiments in which the activating signal is received wirelessly by indicator 118, output port 128 can be configured to transmit the corresponding signal wirelessly to indicator 118.

[0044] Figure 3 shows one embodiment in which a transmitter 130 and receiver 132 are used to wirelessly couple processor 124 and indicator 118. Using transmitter 130 and receiver 132, processor 124 can wirelessly send the activating signal to indicator 118. Any type of couplable wireless transmitter and receiver as are now known in the art or that may become known in the art can be used. For example, transmitter 130 and receiver 132 can comprise devices that communicate with each other using RF, infrared, Bluetooth, or any other type of wireless transmission system.

[0045] Returning to Figure 2, processor 124 analyzes the signals received at input ports 126 to determine if a correction is warranted in the running step of the runner, and alerts the runner accordingly by transmitting the activating signal to indicator 118 using output 128. Various methods of analyzing the inputs and signaling the user will be discussed in more detail below.

[0046] The processes performed by processor 120 can be accomplished using electronic hardware alone, or in conjunction with computer-executable instructions. As such, embodiments of processor 120 may comprise or utilize a special purpose computer having one or more microprocessors and system memory. Embodiments of processor 120 may also include physical storage media and other computer-readable media for storing computer-executable instructions and/or data structures which are used by the one or more computing microprocessors. Such computer-readable media can be any available media that can be accessed by a general purpose or special purpose computer. Computer-readable media that store computer-executable instructions are physical storage media. Computer-readable media that carry computer-executable instructions are transmission media. Thus, by way of example, and not limitation, embodiments of the present invention may comprise at least two distinctly different kinds of computer-readable media: physical storage media and transmission media.

[0047] Physical storage media used in embodiments of the present invention may include RAM, ROM, and EEPROM or any other medium which can be used to store desired program code means (i.e., software) in the form of computer-executable instructions or data structures and which can be accessed by the one or more microprocessors of a special purpose computer to implement aspects of the invention, such that they are not merely transitory carrier waves or propagating signals.

[0048] Computer-executable instructions comprise, for example, instructions and data which, when executed by one or more microprocessors, cause a general purpose computer, special purpose computer, or special purpose processing device to perform a certain function or group of functions, including the functions described herein, as aspects of the invention. The computer executable instructions may be, for example, binaries, intermediate format instructions such as assembly language, or even source code. Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the described features or acts described above. Rather, the described features and acts are disclosed as example forms of implementing the claims.

[0049] Remaining with Figure 2, step analyzing apparatus 102 can include a power source 134, such as a standard or custom battery or batteries, to power the components of step analyzing apparatus 102. Step analyzing apparatus 102 can also include a system activator 136, such as a switch or button, to turn analyzing apparatus 102 on and off or to switch between different modes of operation. System activator 136 can be positioned on the outside of the shoe, where it is more easily accessible, although that is not required. Other power sources and system activators, as are presently known in the art or may become so in the future, can also be used. In some embodiments, step analyzing apparatus 102 can turn on and off automatically, as discussed in more detail below, thereby obviating the need for system activator 136. As a result, system activator 136 can be omitted in those embodiments, if desired.

[0050] Portions of step analyzing apparatus 102 discussed above can be mounted on one or more substrates 138 to aid in mounting and positioning step analyzing apparatus 102 within a shoe. For example, in the embodiment depicted in Figures 1 and 2, three separate substrates 138a, 138b, and 138c are depicted, respectively corresponding to the heel, the midfoot, and the arch portions of the foot. In the depicted embodiment, first sensor 110a is positioned on substrate 138a so as to be positioned under the heel, second sensor 110b is positioned on substrate 138b so as to be positioned under the midfoot, and indicator 118, processor 124, and power source 134 are positioned on substrate 138c so as to be positioned between the heel and the midfoot. Wires or other flexible wiring components 116 can be used to pass signals between substrates 138.

[0051] Substrates 138 can be comprised of a rigid but more commonly flexible material. Common materials for substrate 138 include fabric, or one or more thin layers of polymeric material, polymeric foam, rubber, silicone, or the like. In some embodiments, one or more of the substrates can form a flexible circuit, as is known in the art, to include circuit traces of step analyzing apparatus 102. To minimize obstruction with the foot, in one embodiment, sensors 110, indicator 118, power source 134, and/or processor 124 can have a maximum thickness extending between a top surface and opposing bottom surface in a range between about 0.5 mm to about 7 mm with about 0.5 mm to about 4 mm being more common. Other dimensions can also be used. Substrates 138 can have the same range of maximum thickness.

[0052] Although three separate substrates 138a-138c are shown in the depicted embodiment, it is appreciated that more or less substrates can alternatively be used. For example, in some embodiments, sensors 110a and 110b, indicator 118, processor 124, and power source 134 are all positioned on a single substrate. In other embodiments, substrates 138a and 138c can be combined or substrates 138b and 138c can be combined. In one embodiment, the insole or some other portion of the shoe can act as substrate(s) 138 for step analyzing apparatus 102 and substrate(s) 138 can be omitted, as discussed in more detail below. In some embodiments, one or more of the components of step analyzing apparatus 102 may be standalone units that are not mounted on any substrate. If desired, an adhesive can be applied to substrates 138 and/or the different components of analyzing apparatus 102 for securing to a shoe or other structure. For example, substrates 138 and/or the different components of analyzing apparatus 102 can be provided with a peel off layer on one side that covers an adhesive until use.

[0053] Figures 4-6 show various methods of monitoring running steps that can be performed by step analyzing apparatuses according to embodiments of the present invention. Although discussed as three separate methods, many, if not all, of the method steps disclosed in the separate methods can be mixed and matched in the different methods depending on the desired outcome.

[0054] Furthermore, various steps in the methods discussed herein include steps in which detected or computed values are compared against threshold or predetermined values. The threshold or predetermined values can be preset constant values that never change, or can be programmable values changeable by the user. In some embodiments, the processor can automatically set the value(s) based on variables such as the runner's weight, type of stride, etc. For example, in one embodiment a short training run can be made to come up with one or more of the predetermined values. This may be desirable if different runners share a system or if the system is used in different shoes by the same runner.

[0055] For ease in discussion, the methods will be discussed in conjunction with step analyzing apparatus 102, as described above, such that the steps of the method can be performed by processor 124. It should be noted, however, that this is exemplary only and that the methods discussed herein can be performed in conjunction with other step analyzing apparatuses if desired. To perform the methods discussed below, the step analyzing apparatus is first positioned within the runner's shoe so that sensors are positioned under the heel and midfoot of the runner's foot and then turned on. As noted above, in some embodiments system activator 136 is used to manually turn the step analyzing apparatus on and off. In other embodiments, step analyzing apparatus 102 can turn on and off automatically by, e.g., periodically monitoring shoe activity and turning on when a particular trigger occurs, such as one or more forceful contacts with a surface. Other system "wake-up" triggers are also possible.

[0056] With reference to Figure 4, one method 200 of monitoring running steps is shown. At step 202, the step analyzing apparatus determines when a running step has begun or is presently occurring. This can be accomplished, e.g., by processor 124 monitoring the heel and midfoot sensors 110a and 110b to determine when a sufficient force is detected on either sensor to signify that contact with the ground has occurred. Various manners of doing this are discussed in more detail in the methods below. Once it has been determined that a running step is occurring, the method continues to step 204.

[0057] At step 204, the step analyzing apparatus determines, for the present running step, the order in which the heel and the midfoot of the shoe contact the ground. This can be accomplished, e.g., by processor 124 comparing the values of heel and midfoot sensors 110a and 110b to determine which sensor has detected contact with the ground first. Various manners of doing this are discussed in more detail in the methods below. It is noted that in some running styles, the heel does not contact the ground. For example, during runs up steep grades, the heel does not usually touch the ground. Embodiments of the present invention can account for this, as discussed below. Once it has been determined which portion of the shoe has contacted the ground first, the method continues to step 206.

[0058] At step 206, the step analyzing apparatus can notify the runner depending on the outcome of step 204. For example, if the heel is deemed to have contacted the ground first, the runner can be notified accordingly. This can be accomplished, e.g., by processor 124 activating indicator 118, as discussed above. The length of the notification can be whatever length is desired. For example, the notification can last substantially less than a second (a microsecond, a millisecond, etc.), about a second, until the next step occurs, or any other desired length of time. The signal can be a continuous or non-continuous signal, such as a pulsed signal. If the midfoot is deemed to have contacted the ground first, the notification can be omitted.

[0059] After the notification is given (if required) or it has been deemed that notification is not required, the method loops back to step 202 to determine when the next running step occurs. Thus, as shown in the depicted embodiment, once method 200 begins, the method can run in a continuous loop, repeating steps 202, 204, and 206 for each running step until the method is manually or otherwise stopped.

[0060] Based on the above, in one method of monitoring running steps, the method can comprise: sensing through a first sensor when a heel of a foot wearing a shoe causes a heel of the shoe to land against a surface; sensing through a second sensor when a midfoot of the foot wearing the shoe causes a midfoot of the shoe to land against the surface; processing, through an electrical processor, inputs from the first sensor and the second sensor to determine, for a given step of the shoe, whether the heel of the shoe is landing on the surface prior to the midfoot of the shoe; and activating an indicator to generate a notice if, for the given step, the heel of the shoe lands prior to the midfoot of the shoe.

[0061] In some cases, the runner may not want to be notified on every heel-first step. For example, Figure 5 depicts one method 220 of monitoring running steps in which the runner is notified only if a predetermined number of consecutive heel-first steps have occurred.

[0062] At step 222, the processor continuously receives and analyzes inputs from the heel and midfoot sensors. At some point during the receipt and analysis of the sensor inputs, the processor determines from the sensor inputs that the heel and/or midfoot of the shoe has contacted or landed against a surface, as reflected in step 224. The receipt and analysis of the sensor inputs (steps 222 and 224) can be accomplished in a number of ways. For example, an interrupt or a polling approach can be used.

[0063] In the interrupt approach, both sensors can be used as interrupt triggers, as is known in the art, to interrupt the processor when a particular sensor threshold level has been detected. For switch type sensors, the interrupt triggering level can be set to trigger when the sensor switches “on”. For tactile type sensors, the interrupt triggering level can be set to trigger when the detected force or pressure is at or above a predetermined threshold value. One benefit of using the interrupt approach is that the processor can be performing other tasks while waiting because the processor will automatically be interrupted by the interrupt triggers.

[0064] In the polling approach, the processor reads the sensor values in a periodic, continuous loop until the processor detects that at least one of the sensor values is at or above a predetermined threshold value. Similar to the sensor threshold level of the interrupt approach, the predetermined threshold value can be set based on the type of sensor used so that the processor detects when the sensor switches "on" for switch type sensors or when the detected force or pressure is at or above a predetermined threshold value for tactile type sensors. Using the polling approach, the processor is actively involved in processing the sensor values. As such, the processor may not be able to perform many other tasks at the same time. In either approach, the sensor inputs are used to determine which portion of the shoe has contacted the surface.

[0065] As noted above, in some running styles, the heel does not contact the ground. However, in those running styles, the midfoot always contacts the ground. Thus, even when the heel does not contact the ground, the running step will still be detected. Once it has been determined based on the sensor inputs that either the heel or the midfoot of the shoe has contacted the ground, the method continues to step 226.

[0066] At step 226, the processor determines, for the present running step, which portion of the shoe contacted the ground first. This can be accomplished by determining which sensor allowed the processor to determine that the shoe had landed against the surface. For example, in the interrupt approach, the processor can determine which sensor input caused the interrupt to occur. In the polling approach, the processor can determine which sensor input value was at or above the predetermined threshold value. The portion of the shoe associated with the triggering sensor has contacted the surface first. If the heel of the shoe is determined to have contacted the ground first, the method branches to step 228; otherwise the method branches to step 232.

[0067] At step 228, the processor compares the number of consecutive steps in which the heel has landed first ("heel-first steps") with a predetermined number. This can be done, e.g., using a counter, as discussed in more detail below. If the number of consecutive heel-first steps is greater than or equal to the predetermined number, the method branches to step 230; otherwise, the method branches to step 232.

[0068] At step 230, the step analyzing apparatus notifies the runner that the heel of the shoe has contacted the ground before the midfoot for at least the predetermined number of consecutive steps. The predetermined number can be any integer desired by the runner. For example, the predetermined number of consecutive steps can be 2, 3, 4, 5, 10, or any other desired integer. In some embodiments, the predetermined number is variable and can be changed by the runner before or during use of the step analyzing apparatus. In some embodiments, the predetermined number can change dynamically based on factors that occur during running, such as the gait of the runner, the elapsed time of the running session, etc. Once notice has been given to the runner, the method continues to step 232.

[0069] As noted above, the method also branches to step 232 if, at step 228, the number of consecutive heel-first steps is less than the predetermined number, or, at step 226, the midfoot of the shoe is determined to have contacted the ground first. As a result, in those cases, the notification step (step 230) is skipped.

[0070] At step 232, the processor waits for a predetermined period of time to allow the present running step to be completed. After the predetermined period of time has expired, the method returns to step 222 to begin monitoring for the next running step. The waiting period may be needed to allow the present running step to be completed; otherwise, the end of the present running step may be detected in the next steps 222 and 224 and may be erroneously seen as the next running step.

[0071] The predetermined waiting period can be any time period that: i) is long enough to allow the present running step to conclude and ii) is short enough so that the next running step does not occur before the method returns to step 222. For example, the predetermined waiting period can be between about 0.1 seconds and 0.5 seconds with between about 0.1 seconds and 0.3 seconds being common. In some embodiments, the predetermined waiting period varies based on the running pace or other variable. In some embodiments, the running step concludes before the method steps are all performed, thereby making the waiting period unnecessary. In other embodiments, step 232 can be optional depending on the speed of the processor and the gait of the runner, among other things. In embodiments where the waiting period is unnecessary or otherwise undesired, step 232 can be omitted and monitoring of the next running step (step 222) can begin immediately after completion of steps 226, 228, and/or 230.

[0072] Based on the above, in one method of monitoring running steps, the method being performed by a processor positioned in a shoe, the method can comprise: repeating for each running step the following: receiving inputs from a first sensor and a second sensor, the first sensor being configured to indicate when a heel of a foot wearing the shoe causes a heel of the shoe to land against a surface and the second sensor being configured to indicate when a midfoot of the foot wearing the shoe causes a midfoot of the shoe to land against a surface; determining, based on the inputs, when a first one of the heel or the midfoot of the shoe has landed against a surface, and which portion of the shoe has landed first; outputting a signal to an indicator to generate a notice if, including the present running step, the number of consecutive running steps the heel of the shoe has landed first is greater than or equal to a predetermined number; and waiting and ignoring the inputs for a predetermined period of time.

[0073] Figure 6 depicts another method 240 of monitoring running steps in which the runner is notified only if a predetermined number of consecutive heel-first steps have occurred. A heel counter is used to determine when this has occurred. Method 240 uses the polling method, discussed above, to receive and monitor inputs from the heel and midfoot sensors.

[0074] At step 242, the processor receives an input from each of the heel and midfoot sensors and the method continues to step 244.

[0075] At step 244, the value from the midfoot sensor is compared against a first predetermined threshold value. If the midfoot sensor input value is less than the first predetermined threshold value, the midfoot of the shoe is not landing on the ground or is not landing on the ground with sufficient force to warrant a running step and the method continues to step 246.

[0076] At step 246, the value of the input from the heel sensor is compared against a second predetermined threshold value. If the heel sensor input value is less than the second predetermined threshold value, the heel of the shoe is not landing the ground or is not landing on the ground with sufficient force to warrant a running step and the method loops back to step 242. The first and second predetermined threshold values can be the same or different, depending on the types of sensors used, the expected forces encountered, etc. Furthermore, steps 242, 244, and 246 can be used with switch types of sensors or tactile types of sensors, in the manner discussed above.

[0077] The method loop (steps 242, 244, 246) continues until the value of one of the sensor inputs becomes greater than or equal to the respective predetermined threshold value at step 244 or 246. As such, steps 242, 244, and 246 combine to disclose one way of accomplishing steps 222 and 224 of method 220, discussed above.

[0078] At step 244, if the value from the midfoot sensor is greater than or equal to the first predetermined threshold value, the midfoot portion of the shoe has contacted the ground first and the method branches to step 254. Because this is the desired result, no signal is sent to the runner. Furthermore, because the midfoot portion of the shoe has contacted the ground first, the number of consecutive heel-first running steps is now zero.

[0079] At step 254, the heel counter is reset to reflect the reset of the number of consecutive heel-first running steps, and the method continues to step 256 to wait before beginning to monitor the next running step.

[0080] At step 246, if the value from the heel sensor is greater than or equal to the second predetermined threshold value, the heel portion of the shoe has contacted the ground first and the method branches to step 248.

[0081] At step 248, because the heel portion of the shoe has contacted the ground first, the number of consecutive heel-first running steps has increased by one. The heel counter is accordingly incremented. The method then continues to step 250.

[0082] At step 250, the heel counter (which represents the number of consecutive heel-first steps) is compared with the predetermined number. If the heel counter is greater than or equal to the predetermined number, the number of heel-first steps has occurred for at least the predetermined number of consecutive steps. If the heel counter is greater than or equal to the predetermined number, the method branches to step 252; otherwise the method branches to step 256.

[0083] At step 252, the step analyzing apparatus notifies the runner that the heel of the shoe has contacted the ground before the midfoot for at least the predetermined number of consecutive steps. The predetermined number can be any number discussed above with respect to method 220. Once notice has been given to the runner, the method continues to step 256.

[0084] As noted above, the method also branches to step 256 if, at step 244, the midfoot of the shoe is determined to have contacted the ground first, or, at step 250, the number of consecutive heel-first steps is less than the predetermined number. As a result, in those cases, the notification step (step 252) is skipped.

[0085] At step 256, the processor waits for a predetermined period of time to allow the present running step to be completed. After the predetermined period of time has expired, the method returns to step 242 to begin monitoring for the next running step. The predetermined period of time can be any time period discussed above with respect to method 220. Furthermore, the waiting period can be omitted if desired as also discussed above with reference to method 220. For example, in some embodiments, step 256 can be omitted and monitoring of the next running step (step 242) can begin immediately after completion of steps 250, 252, and/or 254.

[0086] The methods discussed above use inputs from two sensors, one at the heel and one at the midfoot, to monitor the running step and alert the runner, when desired. In other embodiments, a single sensor can be used. For example, if a single sensor is used, the sensor can be positioned under the heel. During a running step, if the heel strikes the ground first, a greater force is likely to occur there. Therefore, the processor can monitor the heel sensor and if a great enough force is detected therefrom, the step analyzing apparatus can signal the user that an undesired step has occurred.

[0087] Figures 7 and 8 depict another system 260 for monitoring running steps according to one embodiment. System 260 is similar to system 100 except that instead of most of the components of step analyzing apparatus 102 being mounted on substrates 138, the components of step analyzing apparatus 102 are mounted directly on the top surface 262 of insole 106. For example, as shown in Figure 7, sensors 110, processor 124, power source 134 and indicator 118 can all be mounted on insole 106. If analyzing apparatus 102 is automatically turned on and off so as to obviate the need for an external system activator as discussed above, the analyzing apparatus/insole combination can be a standalone unit. That is, by being mounted on insole 106, step analyzing apparatus 102 can be movable between shoes by simply removing insole 106 from one shoe and positioning insole 106 within another shoe.

[0088] As shown in Figure 8, one or more cavities 264 can be formed on top surface 262 of insole 106 for receiving the mounted components. Cavities 264 may be beneficial so that the runner does not feel any discomfort from step analyzing apparatus 102. Cavities 264 can be of any depth desired. In one embodiment, the depth of cavities 264 is such that the tops of the mounted components of step analyzing apparatus 102 are flush with top surface 262 of insole 106. In another embodiment, the depth of one or more cavities 264 is such that the mounted components are completely recessed within cavities 264 so that a cover 266 can be positioned within each cavity 264 over the mounted components. Although disclosed herein as being mounted on top surface 262, one or more of the step analyzing apparatus components can instead by mounted on bottom surface 268 of insole 106. This may provide more comfort to the user. Similar to top surface 262, bottom surface 268 may also include cavities 270 formed thereon for receiving the components mounted thereon. In one embodiment, the cavities are formed within insole 106 so that once the components have been positioned within the cavities, the components are enclosed within the insole.

[0089] Figure 9 shows another embodiment in which step analyzing apparatus 102 can be easily moved between shoes. In the depicted embodiment, step analyzing apparatus 102 is incorporated within a sock 274. Similar to the other embodiments discussed herein, the heel and midfoot sensors 110a and 110b are respectively positioned to be directly under the heel and midfoot of the user. Step analyzing apparatus 102 can be positioned inside or outside of sock 274, such as by adhesive or stitching, or can be disposed between layers formed on the bottom of sock 274. Other mounting methods can also be used.

[0090] In contrast to being removable from or separately attachable to a shoe, step analyzing apparatus 102 can be secured to sole 108 of a shoe as part of the manufacturing process of the shoe. For example, as depicted in Figure 10, analyzing apparatus 102 can be molded into, i.e., at least partially embedded within, sole 108 as part of the manufacturing process of sole 18, can be secured within cavities formed on the top surface of sole 108 and/or can be molded or otherwise secured onto the top surface of sole 108. Shoe 104 can then be used with insole 106 or without.

[0091] Step analyzing apparatus 102 can also be used to help optimize an athlete's form in other types of athletic steps. For example, Figure 11 shows a system 280 according to one embodiment that can be used for skiing or the like. Similar to the other systems discussed herein, system 280 can include step analyzing apparatus 102 to monitor heel and midfoot sensor inputs and signal the user when bad form is detected.

[0092] In skiing, a traditional running step is not typically used. However, the same type of concept regarding foot forces is used to determine proper ski form in a ski boot 282. Proper ski form typically requires all or most of the weight being placed on the front of the foot, such that the shin of the skier is pressed against a top front portion 284 of ski boot 282. As such, most of the weight of the foot should be centered over the midfoot. Therefore, similar to the methods discussed previously, the processor can monitor the values from midfoot and heel sensors 110a and 110b to determine proper weight placement, and signal the user when improper form is detected.

[0093] For example, in one embodiment, if midfoot sensor 110b indicates a release of foot pressure thereon and heel sensor 110a indicates an increase of foot pressure thereon for a predetermined period of time, such as, e.g., five or ten seconds, step analyzing apparatus 102 can signal the user in one of the manners discussed above. In another embodiment, heel sensor 110a can be the only sensor monitored. In that embodiment, a predetermined amount of force placed on the heel sensor can trigger the step analyzing apparatus 102 to signal the user.

[0094] In another embodiment, one or more sensors can be placed within the ski boot at other locations. The one or more other sensors can be used in place of or in conjunction with heel sensor 110a and/or midfoot sensor 110b. For example, as shown by the dashed lines in Figure 10, sensors 110c and 110d can be respectively positioned at top front and rear portions 284 and 286 of ski boot 282 to align with the shin and calf of the user. Sensors 110c and 110d can be used alone or in conjunction with sensors 110a and 110b to determine proper and improper forces and pressures caused by the skier's leg and foot.

[0095] The systems disclosed herein can also be used to determine if the runner is running at a desirable cadence. Cadence is the tempo at which the runner is taking the running steps and usually constitutes the amount of steps taken for a particular unit of time, such as steps per minute. Thus, relatively speaking, at a faster cadence the runner is taking more steps per unit of time and therefore less time elapses between steps. Conversely, at a slower cadence lower cadence the runner is taking fewer steps per unit of time and therefore more time elapses between steps. A runner may have a cadence range that is desirable to optimize power or speed, conserve energy, or optimizes some other aspect of running. For example, an efficient cadence may be 85-90 steps per foot per minute, or 170-180 total steps per minute. The systems disclosed herein can be used to determine if the runner is running within a predefined desirable cadence range.

[0096] For example, Figures 12-14 show various methods of monitoring running cadence that can be performed by step analyzing apparatuses according to embodiments of the present invention. Although discussed as three separate methods, many, if not all, of the method steps disclosed in the separate methods can be mixed and matched in the different methods depending on the desired outcome. Furthermore, any of the cadence monitoring methods can be performed concurrently with any of the running step monitoring methods, if desired.

[0097] With reference to Figure 12, one method 300 of monitoring running cadence is shown. At step 302, the step analyzing apparatus determines the cadence of the present running step. This can be accomplished, e.g., by processor 124 determining when consecutive steps have taken place in one of the manners discussed above, and then determining the time between the steps. Because the detected steps are taken by the same foot, the cadence value will correspond to steps taken by the same foot. Thus, the steps taken by the opposite foot, which fall in between the detected steps, are not taken into account. If the cadence of all steps (i.e., of both feet) is desired, the detected cadence value can be multiplied by two. Once the cadence has been determined, the method continues to step 304.

[0098] At step 304, the determined cadence is compared with a desired range and the user is alerted if the determined cadence is outside of the desired range.

[0099] Figure 13 depicts another method 310 of monitoring running cadence.

[00100] At step 312, the step analyzing apparatus determines when a present step has begun. Once the present step has been detected, the method continues to step 314.

[00101] At step 314, the step analyzing apparatus determines the elapsed time between the start of the prior step and the start of the present step and the method continues to step 316.

[00102] At step 316, the elapsed time determined in step 314 is compared to a desired time range corresponding to a desired cadence. For example, if the desired cadence range is 85-90 steps per foot per minute, then the elapsed time of the steps of the same foot would need to be between 667 and 706 milliseconds. If the elapsed time is within the desired time range, no alert is needed and the method loops back to step 312. If the elapsed time is not within the desired time range, the method branches to step 318, where the step analyzing apparatus notifies the runner that the cadence is not within the desired time range, before the method returns to step 312.

[00103] Figure 14 depicts another method 320 of monitoring running cadence. Because the midfoot contacts the ground with every step, the midfoot sensor alone can be used to detect cadence. Therefore, method 320 only uses the midfoot sensor.

[00104] At step 322, the processor receives an input from the midfoot sensor and the method continues to step 324.

[00105] At step 324, the value from the midfoot sensor is compared against a predetermined threshold value. If the midfoot sensor input value is less than the predetermined threshold value, the midfoot of the shoe has not yet contacted the ground and the method loops back to step 322. The method loop (steps 322 and 324) continues until the value of the midfoot sensor input becomes greater than or equal to the predetermined threshold value at step 324. At step 324, if the value from the midfoot sensor is greater than or equal to the predetermined threshold value, the midfoot portion of the shoe has contacted the ground first and the method branches to step 326.

[00106] At step 326, the processor determines the elapsed time between the start of the prior running step and the present running step by using a cadence timer. The cadence timer is then reset for the next running step and the method continues to step 328.

[0107] At step 328, the elapsed time is compared to a desired time range corresponding to a desired cadence. If the elapsed time is within the desired range, no alert is needed and the method branches to step 332. If the elapsed time is not within the desired range, the method branches to step 330, where the step analyzing apparatus notifies the runner that the cadence is not within the desired range. Once the notification has occurred, the method then continues to step 332.

[0108] At step 332, the processor waits for a predetermined period of time to allow the present running step to be completed. After the predetermined period of time has expired, the method returns to step 322 to begin monitoring for the next running step. Step 332 is similar to step 232 of method 220, discussed above, and can have the same options and limitations as those discussed above.

[0109] In contrast to determining cadence based on a single step, it is also appreciated that the cadence timer used in conjunction with the step analyzing apparatus can be used to measure the amount of time needed to complete a predetermined number of steps or the number of steps that can be completed in a predetermined amount of time. From this information, the processor can determine the actual cadence and compare it to a predetermined cadence. If the actual cadence is below the desired cadence, a notice to the user would be generated. If the actual cadence is within the desired range or above a predetermined value, the process of determining the actual cadence over a period of steps or time would be repeated.

[0110] Figure 15 illustrates another system 340 that can be used by method 320 to monitor cadence. System 340 includes a cadence analyzing apparatus 342 that can, similar to embodiments discussed above, alert the user when an undesired cadence is detected. As such, cadence analyzing apparatus 342 also includes indicator 118, processor 124 and power source 134. Similar to step analyzing apparatus 102, cadence analyzing apparatus 342 also includes a sensor 344 within the shoe 104a housing processor 124 and indicator 118. However, unlike sensors 310, sensor 344 is positioned on the side of shoe 104a closest to the runner's opposite shoe 104b and does not detect a force or pressure. Instead, sensor 344 is configured to detect a magnetic field.

[0111] A magnet 346 is mounted onto the side of the runner's shoe 104b that faces sensor 344 so as to pass by sensor 344 during the running step. As the runner runs, magnet 346 passes by sensor 344 at the same point during each running step. As magnet 346 passes by sensor 344, the magnetic field at sensor 344 increases and sensor 344 detects the passage of magnet 346 thereby. Method 320 can be used with magnet sensor with little, if any, modifications. As such, the cadence can be monitored and the user signaled when an undesirable cadence is detected by cadence analyzing apparatus 342. If desired, sensor 344 and magnet 346 can be added to step analyzing apparatus 102, if desired, to monitor the cadence concurrently with monitoring of the running step.

[0112] Depicted in Figure 16 is another alternative embodiment of a step analyzing apparatus 102a implemented into shoe 104 and incorporating features of the present invention. Like elements between step analyzing apparatus 102 and 102a are identified by like reference characters. Step analyzing apparatus 102a includes sensors 110a and 110b disposed on or within insole 106 so as to be disposed under the heel and midfoot of a runner's foot. As in other embodiments, sensors 110a and 110b can also be disposed on or within sole 108 or on sock 274. Electrical wire 116a has a first end in electrical communication with sensor 110a while electrical wire 116b has a first end in electrical communication with sensor 110a. Electrical wires 116a and b also have an opposing second end that extends out of insole 106 and couples with an electrical connector 370. Electrical wires 116a and b are typically long enough so that when sensors 110a and 110b are positioned within shoe 104, wires 116a and b can freely travel up the inside surface of shoe 104 and out of mouth 372 thereof so that electrical connector 370 is disposed outside of shoe 104.

[0113] Analyzing apparatus 102a further comprises a controller 374. As depicted in Figure 17, controller 374 comprises a housing 376 which, in the present embodiment, includes a front cover 378 and an opposing back cover 380 that couple together. Disposed within housing 376 is a circuit board 382 having a first side 383 and an opposing second side 385. Mounted in electrical communication to circuit board 382 on first side 383 is processor 124, a switch 384, which is one example of a system activator, and a display light 386 such as an LED. Electrical wires 388 have a first end 389 coupled to an electrical connector 390 and an opposing second end 392 electrically coupled to circuit board 382. As depicted in Figure 18, mounted in electrically communication to circuit board 382 on second side 385 is power source 134. In the depicted embodiments, power source 134 comprises a plurality of batteries such as three AA or AAA batteries. Other numbers of batteries such as one, two, or four or more batteries can be used and other sizes of batteries can also be used. Also mounted to second side 385 of circuit board 382 is indicator 118. Indicator 118 in this embodiment typically comprises a vibrator but other indicators as discussed herein can also be used. Indicator 118 is electrically coupled to circuit board 382 by an electrical wire 394. A button 396 is disposed on front cover 378 and can move relative to front cover 378 by being selectively depressed. As button 396 is depressed, button 396 pushes against switch 384 for activation thereof as discussed below in greater detail. In alternative embodiments, an opening can be formed on front cover in alignment with switch 384 so that switch 384 can be manually activated through the opening. A window 398 can also be mounted on front cover 378 in alignment with display light 386. As such, light from display light 386 shines through window 398. Although controller 374 is shown as housing indicator 118, it is appreciated that indicator 118 along with other components, such as processor 124, could be moved back to within shoe 104 or, through the use of a transmitter and receiver, to other desired locations.

[0114] As depicted in Figure 16, controller 374 can be mounted to the ankle of a user by way of an ankle strap 402. Ankle strap 402 comprises a central body 404 having a first arm 406 and an opposing second arm 408 projecting from opposing sides thereof. Central body 404 and arms 406 and 408 can be formed from a continuous sheet of material such as woven fabric, plastic sheeting, neoprene, leather, or the like. In one embodiment of the present invention, means are provided for removably securing controller 374 to central body 404. By way of example, an outer cover 412 can be secured over central body 404 so as to form a pocket 410 between central body 404 and outer cover 412. Outer cover 412 can be made of the same material as central body 404 and can also extend over arms 406 and 408. Pocket 410 is formed with a mouth 414 at an upper end of central body 404 through which controller 374 can be received within pocket 410. A smaller passage 416 is formed between central body 404 and outer cover 412 at the lower end of central body 404 through which wires 388 and electrical connector 390 can pass. An opening 418 extends through the side of outer cover 412 so that when controller 374 is received within pocket 410, button 396 and window 398 are aligned with opening 418. In alternative embodiments of the means for removably securing controller 374 to central body 404, outer cover 412 can be replaced with a clip, container, clamp, straps, or other types of fasteners or retainers that are secured central body and configured to securely hold controller 374.

[0115] Arms 406 and 408 are also formed with one or more fasteners so that when arms 406 and 408 are wrapped around an ankle, arms 406 and 408 can be releasably secured together for securing ankle strap 402 to an ankle and thereby secure controller 374 to the ankle. In one embodiment, fastener 420 comprises Velcro, e.g., loop material 422 can be placed on a front face of first arm 406 while hook material 424 is placed on the back face of second arm 408. When arms 406 and 408 are wrapped around an ankle, loop material 422 and hook material 424 overlap and bind together. It is appreciated that a variety of the fasteners can also be used such as buttons, hooks, belt fasteners, snaps, and the like.

[0116] It is appreciated that processor 124 can be loaded with a computer program that enables step analyzing apparatus 102a to operate in a number of different modes. For example, step analyzing apparatus 102a can operate in the mode to detect whether the heel is landing before the midfoot or at a variety of different cadence levels as previously discussed. In one specific example of operation, step analyzing apparatus 102a can be programmed so that when button 396 is first pushed, display light 386 flashes red designating that step analyzing apparatus 102a is turned off or in walking mode. When button 396 is pushed again, display light 386 flashes orange designating that step analyzing apparatus 102a is operating to detect whether the heel is landing before the midfoot. When button 396 is pushed a third time, display light 386 flashes green/red designating that step analyzing apparatus 102a is operating in a cadence mode of 86 steps per foot per minute. If button 396 is pushed a fourth time, display light 386 flashes green/orange designating that step analyzing apparatus 102a is operating in a cadence mode of 88 steps per foot per minute. Finally, if button 396 is pushed a fifth time, display light 386 flashes green/green designating that step analyzing apparatus 102a is operating in a cadence mode of 90 steps per foot per minute. When button 396 is pushed again, display light 386 again flashes red and the modes of operation can be cycled through again. It is appreciated that processor 124 can be programmed to operate in any number of different modes and that a variety of different mechanisms and displays can be used to switch between different modes and to designate different modes.

[0117] During use, the mode of operation is manually set either before or after controller 374 is positioned within pocket 410 of ankle strap 402. Ankle strap 402 can be secured to a user's ankle either before or after controller 374 is positioned within pocket 410. Electrical connector 390 of controller 374 is typically connected to electrical connector 370 coupled with sensors 110, after controller 374 is secured to the ankle. An identical controller 374 with corresponding ankle strap 402 can also be secured and electronically connected to sensors 110 on the other ankle. The system is no ready for running. At any time, each step analyzing apparatus 102a can be changed to a different mode. Likewise, each step analyzing apparatus 102a can be set to the same mode of operation or to a different mode of operation. For example, on one foot the system can be set to detect midfoot to heel running while the system on the other foot can be set to detect cadence. Where it is no longer desirable to run with controllers 374, electrical connectors 390 and 370 can be disconnected and controller 374 and ankle strap 402 removed. The runner can then still continue to run with sensors 110a and b within the runner's shoes.

[0118] In one embodiment of the present invention, it is desirable that the step analyzing apparatus only operate while a user is running. The determination of whether a user is running can be based upon the load applied to sensors 110. However, depending on the weight of the user, how tight the shoe laces are tied, running style, and other factors, the load applied to sensors 110 can vary dramatically. Thus, to improve operational efficiency, sensors 110 can be calibrated at the start of each use.

[0119] In one example of calibration, the user can be told to initially walk in the shoes containing the step analyzing apparatus so that the step analyzing apparatus can detect the maximum amount of force that is applied to sensors 110 during walking. The step analyzing apparatus can then be set or calibrated to only operate when sensors 110 sense a force that is greater than the measured maximum force that is applied to sensors 110 during walking. In another embodiment, the calibration can be based on initial running steps. In this embodiment, the step analyzing apparatus can be set or calibrated to only operate when sensors 110 sense a force that is greater than a percentage, e.g., 95%, 90%, 80%, or other percentages, of the force that is measured by sensors 110 during the initial running steps.

[0120] Set forth in Figure 19 is a block diagram outlining one example of how the step analyzing apparatus can be calibrated. At step 400 a one second timer, which is part of the step analyzing apparatus, is activated. As will be discussed below, when the measured one second ends, the time and other stored values are automatically reset. The timer makes sure that each calibration for a sensor 110 is based on a single step and not values from multiple steps.

[0121] In step 401 the input from one of sensors 110 is checked. In step 402 it is determined whether the pressure measured from the sensor in step 401 is greater than or equal to a predetermined threshold value. This initial threshold value is very small, such as what would be expected if a person was just standing but not walking. If the measured value is less than the threshold value, the process cycles back to step 401. If the measure value is greater than the threshold value, the process moves to step 404 and the measured pressure value is stored. Next, in step 406, the input from the same sensor 110 is again checked. In step 408, it is determined whether the measured pressure in step 406 is greater than the stored pressure in step 404. If yes, that means that more force is still being applied to the sensor for a given step, i.e., the force being applied to the sensor by the walking step has not yet reached its apex. In this case, the process repeats to step 404 where the stored pressure value is replaced with the higher measured pressure value from step 406. Steps 406 and 408 are then again repeated. If in step 408 the measured pressure value from step 406 is less than the stored pressure value in step 404, the walking step has passed its apex with regard to the force being applied to that sensor. The maximum pressure value from step 404 and 406 is then stored in step 410.

[0122] Step 412 determines whether 3 maximum pressure values have been stored in step 410, i.e., whether the process been repeated three times. If not, the process cycles back to step 400. It is noted that each time the one second timer in step 400 resets, the process being carried out through steps 400-408 automatically resets. Again, this ensures that only the values for a single step are measured. Once three maximum pressure values are obtained in step 412, the pressure reference value is set in step 414. Depending on whether the measured pressure values are based on walking or running, the pressure reference valve can be the greater of the three values in step 412, the average of the three values, a percentage of the foregoing, or some other value based on one or more of the values in step 412. Once the pressure reference value is obtained for both sensors 110a and 110b, the calibration is complete and the user is notified in step 416 through indicator 118.

[0123] The above calibration process can be completed prior to use of the step analyzing apparatus in any of the previously discussed modes of operation. Once the step analyzing apparatus is calibrated, it can be programmed so that it will not fully operate in any mode of operation until one of sensors 110 reads a pressure greater than the corresponding pressure reference value. It is appreciated that a variety of other ways can also be used to calibrate sensors 110.

[0124] Depicted in Figure 20 is another example of how the step analyzing apparatus can operate in the mode of detecting whether the heel or midfoot is landing first. In step 424, the sensors 110 are initially calibrated as previously discussed with regard to Figure 19. Next, in step 426 a one second timer is activated which automatically resets every second. In step 428 the inputs from the electrical sensors are checked to determined applied pressure. Step 430 determines whether the measured pressure is greater than the set pressure reference value from step 424. If no, the process returns to step 428. If yes, in step 432 the processors determines whether the measured pressure is coming from the sensor at the heel or at the midfoot. If at the heel, step 434 determines whether the time between activation and resetting of the timer in step 426 is greater than or equal to a predetermined threshold value.

[0125] The threshold value is set at a time slightly greater than the time it takes for the midfoot to strike the ground directly after the heel strikes the ground in a single continuous step. This time is significantly shorter than one second. Thus, if the measured time value is smaller than the predetermined value, it is deduced in step 436 that the heel struck first following by the midfoot. This is because in step 440 the timer automatically resets once pressure on the midfoot is detected. Thus, the measured time would be very short because the midfoot would strike shortly after the heel, thus quickly resetting the timer in step 426. Once it is determined that the heel struck first, the user is alerted in step 440 by indicator 118, the information can be recorded in step 442 and the process is then repeated.

[0126] In contrast, if the measured time value is greater than the predetermined threshold value, it is deduced in step 438 that the midfoot struck first and that the pressure from the heel is being measure after the midfoot. This is because the measured time will be relatively long because the timer instep 426 will not be reset until the one second of box 426 expires. Again the information can be recorded in step 442 and the process repeated. As previously referenced, if at step 432 it is determined that the pressure is coming from the sensor at the midfoot, the timer is reset at step 441 and the process is repeated. It is again appreciated that other methods can also be used for detecting whether the heel or midfoot of a user is landing first.

[0127] The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

CLAIMS

What is claimed is:

1. A system for monitoring running steps, the system comprising:

a shoe; and

a step analyzing apparatus, comprising:

a first sensor located within the shoe, the first sensor being configured to transmit a first signal when a heel of a foot wearing the shoe causes a heel of the shoe to land against a surface;

a second sensor located within the shoe, the second sensor being configured to transmit a second signal when a midfoot of a foot wearing the shoe causes a midfoot of the shoe to land against a surface;

an indicator configured to generate a notice when activated; and

a processor in electrical communication with the first sensor, the second sensor, and the indicator, the processor being configured to activate the indicator when the processor determines, based on the first and second signals, that for a given step of the shoe the heel of the shoe is landing prior to the midfoot of the shoe.

2. The system as recited in claim 1, wherein at least one of the first and second sensors comprises a tactile sensor that senses the amount of force or pressure generated thereagainst, the tactile sensor comprising one of the following: a transducer, a force sensor, a pressure sensor, and a strain gauge.

3. The system as recited in claim 1, wherein at least one of the first and second sensors comprises a switch that senses when a force or pressure greater than or equal to a predetermined amount is generated thereagainst, the switch comprising one of the following: a force switch, a pressure switch, and a gravity switch.

4. The system as recited in claim 1, wherein the indicator comprises one or more of the following: a vibrator, a speaker, and a visual display device.

5. The system as recited in claim 1, further comprising a transmitter and a receiver, wherein the indicator is wirelessly coupled to the processor via the transmitter and receiver.

6. The system as recited in claim 1, wherein the shoe comprises a sole and an

insole overlying the sole, the first and second sensors and the processor being disposed between the insole and the sole.

7. The system as recited in claim 1, wherein the shoe comprises a sole, the first and second sensors being secured to the sole.

8. The system as recited in claim 1, further comprising an insole removably positioned within the shoe, the first and second sensors being mounted to the insole.

9. The system as recited in claim 1, further comprising a sock at least partially positioned within the shoe, the first and second sensors being mounted to the sock.

10. The apparatus as recited in claim 1, wherein the processor is configured to also activate the indicator when the processor determines, based on the first and second signals, that for a given step of the shoe the amount of time between consecutive steps is greater than a predetermined threshold value.

11. The apparatus as recited in claim 1, wherein the processes is located within the shoe.

12. The apparatus as recited in claim 1, wherein the step analyzing apparatus further comprises a controller, the controller including:

a housing disposed outside of the shoe;

the processor disposed within the housing; and

the indicator at least partially disposed within the housing.

13. The apparatus as recited in claim 12, further comprising an electrical connector that facilitates electrical connection between the controller and the first and second sensors and permits select separation between the controller and the first and second sensors.

14. The apparatus as recited in claim 13, further comprising an ankle strap that removably secures the controller to an ankle of the wearer of the shoe.

15. The apparatus as recited in claim 12, wherein the processor is also configured to activate the indicator when the processor determines, based on at least one of the first and second signals, that the shoe is landing at a cadence that is less than a predetermined cadence.

16. The apparatus as recited in claim 12, wherein the controller further comprises a switch that converts the processor from determining when the shoe is landing prior to the midfoot of the shoe to determining when the shoe is landing at a cadence that is less than a predetermined cadence.

17. A method of monitoring running steps, the method comprising:

sensing through a first sensor when a heel of a foot wearing a shoe causes a heel of the shoe to land against a surface;

sensing through a second sensor when a midfoot of the foot wearing the shoe causes a midfoot of the shoe to land against the surface;

processing, through an electrical processor, inputs from the first sensor and the second sensor to determine, for a given step of the shoe, whether the heel of the shoe lands on the surface prior to the midfoot of the shoe; and

activating an indicator to generate a notice if, for the given step, the heel of the shoe lands prior to the midfoot of the shoe.

18. The method as recited in claim 17, wherein sensing through the first sensor when the heel of the foot wearing the shoe causes the heel of the shoe to land against the surface comprises determining when an amount of force generated by the heel of the foot against the first sensor is greater than a predetermined threshold value.

19. The method as recited in claim 17, wherein sensing through the electrical second sensor when the midfoot of the foot wearing the shoe causes the midfoot of the shoe to land against the surface comprises determining when an amount of force generated by the midfoot of the foot against the second sensor is greater than a predetermined threshold value.

20. The method as recited in claim 17, wherein activating the indicator to generate the notice comprises activating a vibrator electrically coupled with the electrical processor.

21. The method as recited in claim 17, wherein activating the indicator to generate the notice comprises activating the indicator when the heel of the shoe lands prior to the midfoot of the shoe on the given step only if the heel of the shoe has landed prior to the midfoot of the shoe on a predetermined number of consecutive steps immediately preceding the given step.

22. The method as recited in claim 17, further comprising:

determining, by the electrical processor, the amount of time that elapses between the given step and the step immediately preceding the given step; and

activating the indicator to generate a second notice if, for the given step, the amount of elapsed time is not within a predetermined range.

23. The method as recited in claim 17, further comprising:

switching the electrical processor to operate in a second mode;

determining a cadence of the shoe landing against the surface by the electrical processor receiving the inputs from at least one of the first and second sensors and using the inputs to determine the number of shoe landings per unit of time; and

activating the indicator to generate a notice if the determined cadence is less than a predetermined cadence.

24. The method as recited in claim 17, further comprising calibrating the first sensor and the second sensor so that the step of processing, through an electrical processor, is not performed unless the first sensor or second sensors senses a pressure greater than a pressure reference value.

25. A method of monitoring running steps, the method being performed by a processor, the method comprising:

repeating for each running step:

receiving inputs from a first sensor and a second sensor, the first sensor being configured to indicate when a heel of a foot wearing the shoe causes a heel of the shoe to land against a surface and the second sensor being configured to indicate when a midfoot of the foot wearing the shoe causes a midfoot of the shoe to land against a surface;

determining, based on the inputs, when a first one of the heel or the midfoot of the shoe has landed against a surface, and which portion of the shoe has landed first;

outputting a signal to an indicator to generate a notice if, including the present running step, the number of consecutive running steps the heel of the shoe has landed first is greater than or equal to a predetermined number; and

waiting and ignoring the inputs for a predetermined period of time.

26. The method of monitoring running steps as recited in claim 25, wherein outputting a signal to an indicator to generate a notice comprises:

incrementing a heel counter if the heel of the shoe has landed first;

outputting the signal to the indicator to generate the notice if the heel counter is greater than or equal to the predetermined number of consecutive running steps; and resetting the heel counter to zero if the midfoot of the shoe has landed first.

27. The method as recited in claim 25, wherein at least one of the first and second sensors comprises a tactile sensor that senses the amount of force or pressure generated thereagainst by the foot, and the inputs received from the corresponding sensors comprise signals representative of the amount of force or pressure sensed by the tactile sensor.

28. The method as recited in claim 25, wherein at least one of the first and second sensors comprises a switch that senses when a force or pressure greater than a predetermined threshold value is generated thereagainst by the foot, and the inputs received from the corresponding sensors comprise signals indicating the presence or absence of the predetermined threshold value of force or pressure against the switch.

29. The method as recited in claim 25, further comprising:

switching the electrical processor to operate in a second mode;

determining a cadence of the running steps by the electrical processor receiving the inputs from at least one of the first and second sensors and using the inputs to determine the number of running steps per unit of time; and

activating the indicator to generate a notice if the determined cadence is less than a predetermined cadence.

30. A method of monitoring running steps, the method comprising:

sensing through a first sensor when a foot wearing a shoe causes the shoe to land against a surface;

transmitting an electrical signal from the first sensor to an electrical processor each time the shoe lands against the surface;

determining a cadence of the shoe landing against the surface by the electrical processor using the electrical signals to determine the number of shoe landings per unit of time; and

activating the indicator to generate a notice if the determined cadence is less than a predetermined cadence.

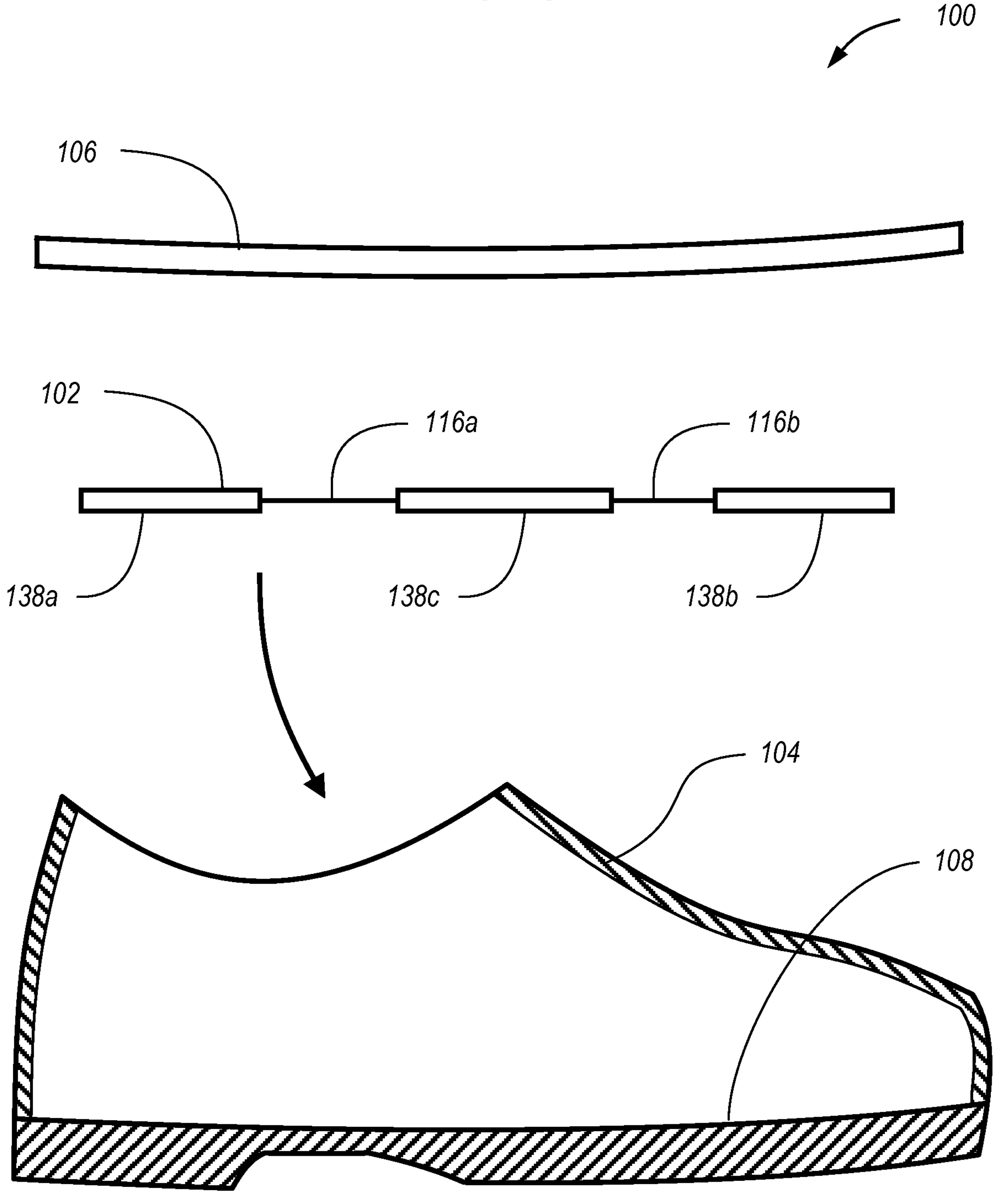
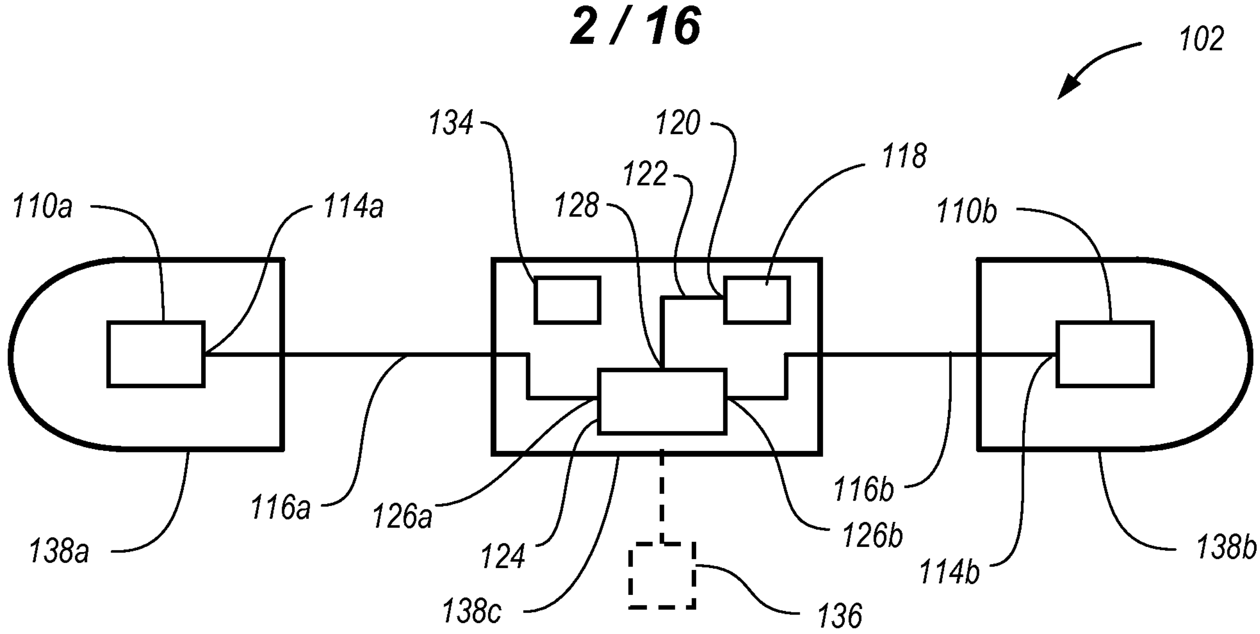


Fig. 1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134
120
118
122
128
110a
114a
110b
116a
126a
124
138c
138a
136
116b
126b
114b
138b

Fig. 2

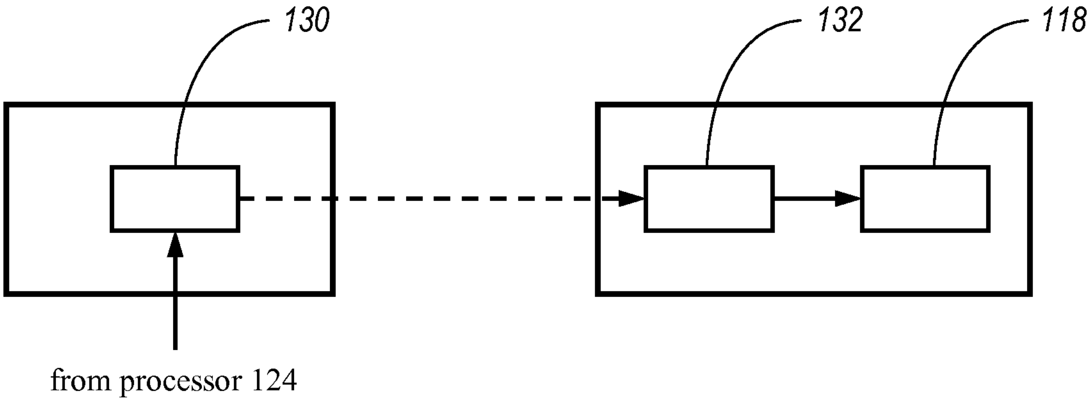

130
132
118
from processor 124

Fig. 3

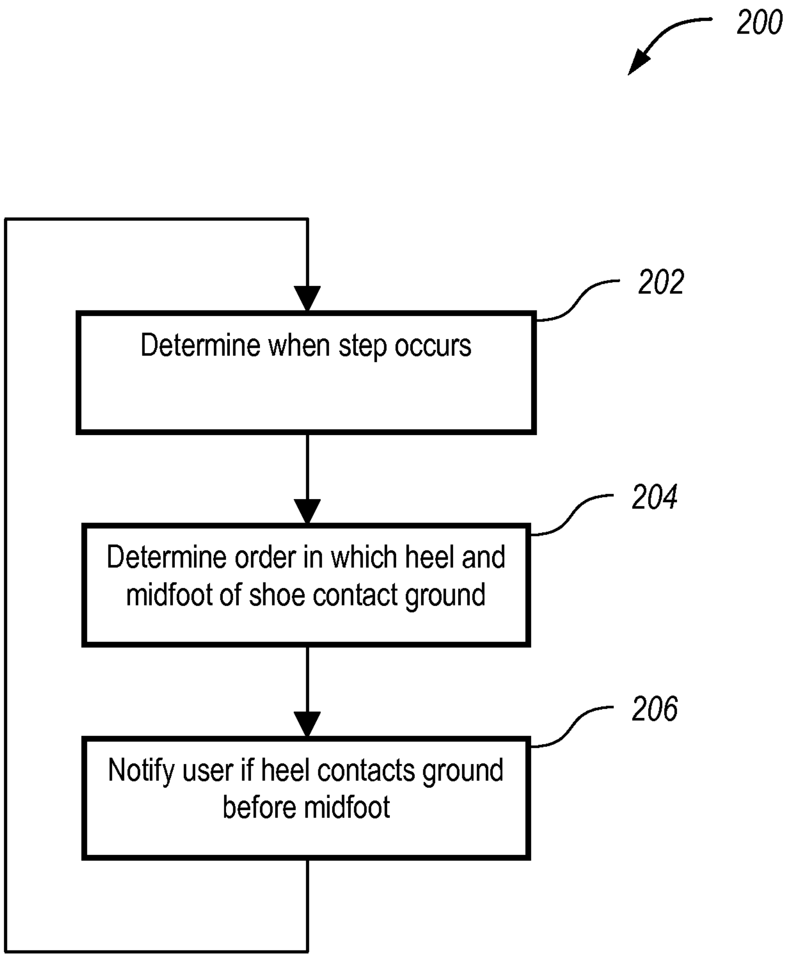

200
202
Determine when step occurs
204
Determine order in which heel and midfoot of shoe contact ground
206
Notify user if heel contacts ground before midfoot

Fig. 4

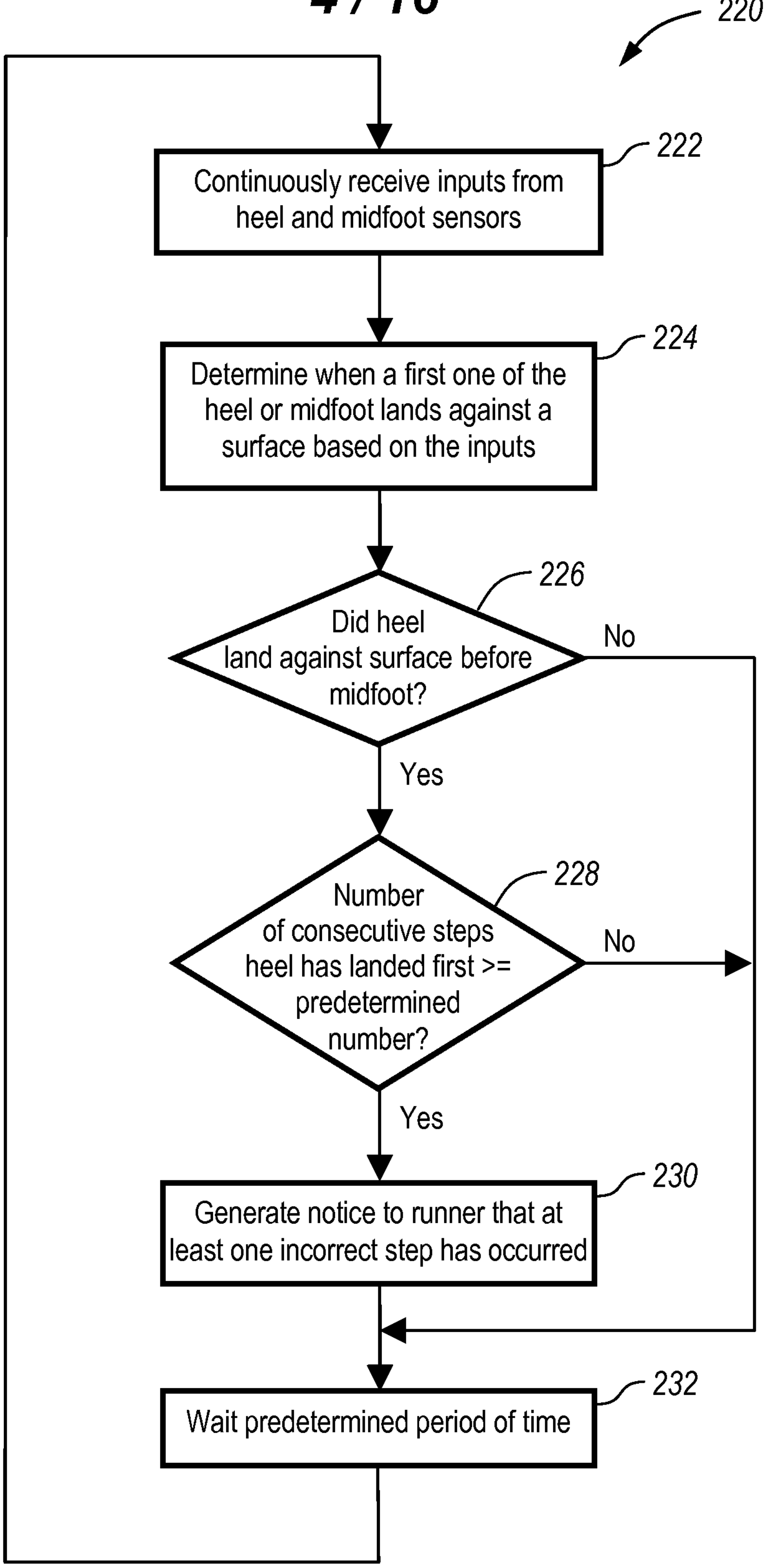

220
222
Continuously receive inputs from heel and midfoot sensors
224
Determine when a first one of the heel or midfoot lands against a surface based on the inputs
226
Did heel land against surface before midfoot?
No
Yes
228
Number of consecutive steps heel has landed first >= predetermined number?
No
Yes
230
Generate notice to runner that at least one incorrect step has occurred
232
Wait predetermined period of time

Fig. 5

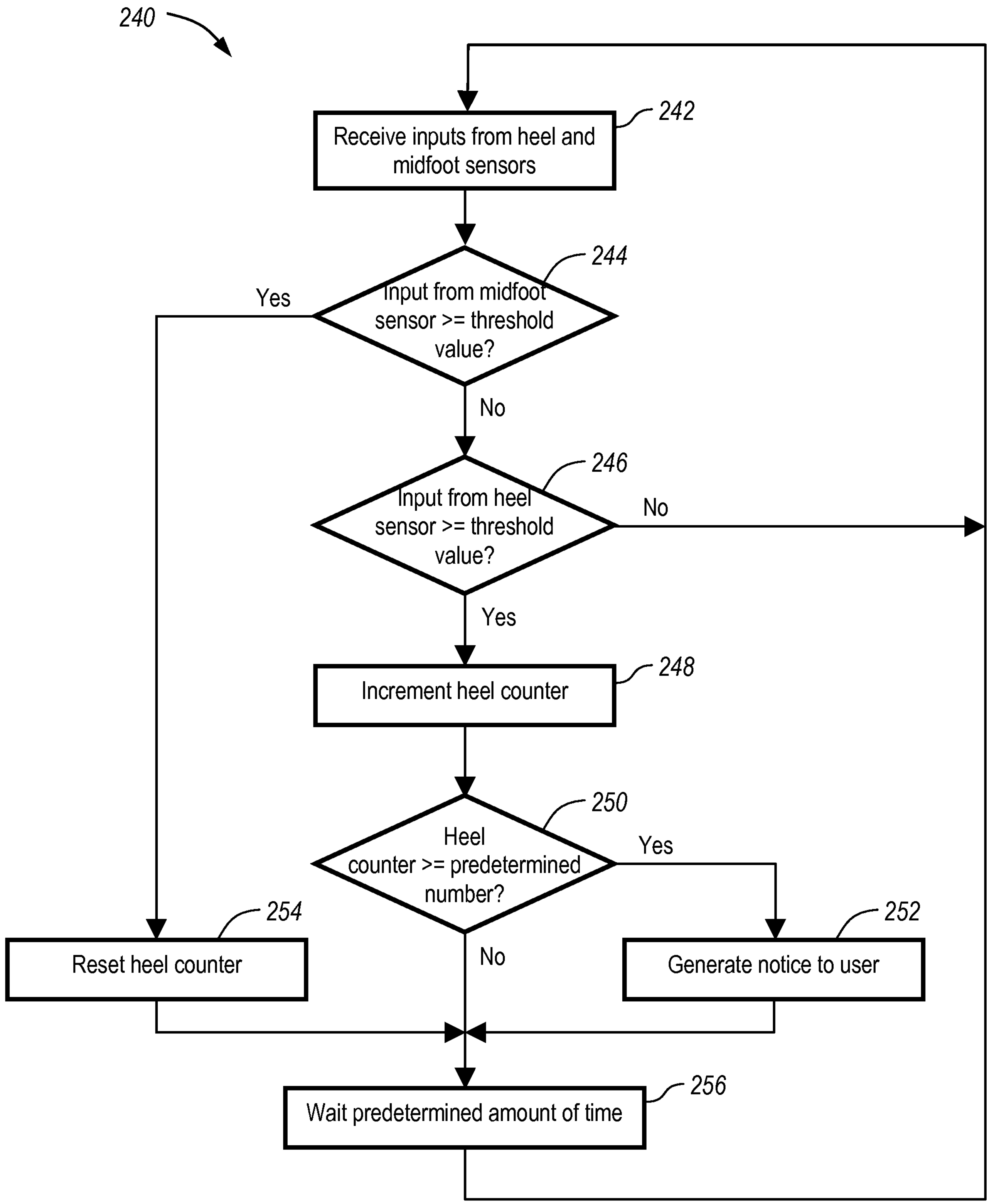

240
242
Receive inputs from heel and midfoot sensors
244
Input from midfoot sensor >= threshold value?
Yes
No
246
Input from heel sensor >= threshold value?
No
Yes
248
Increment heel counter
250
Heel counter >= predetermined number?
Yes
No
254
Reset heel counter
252
Generate notice to user
256
Wait predetermined amount of time

Fig. 6

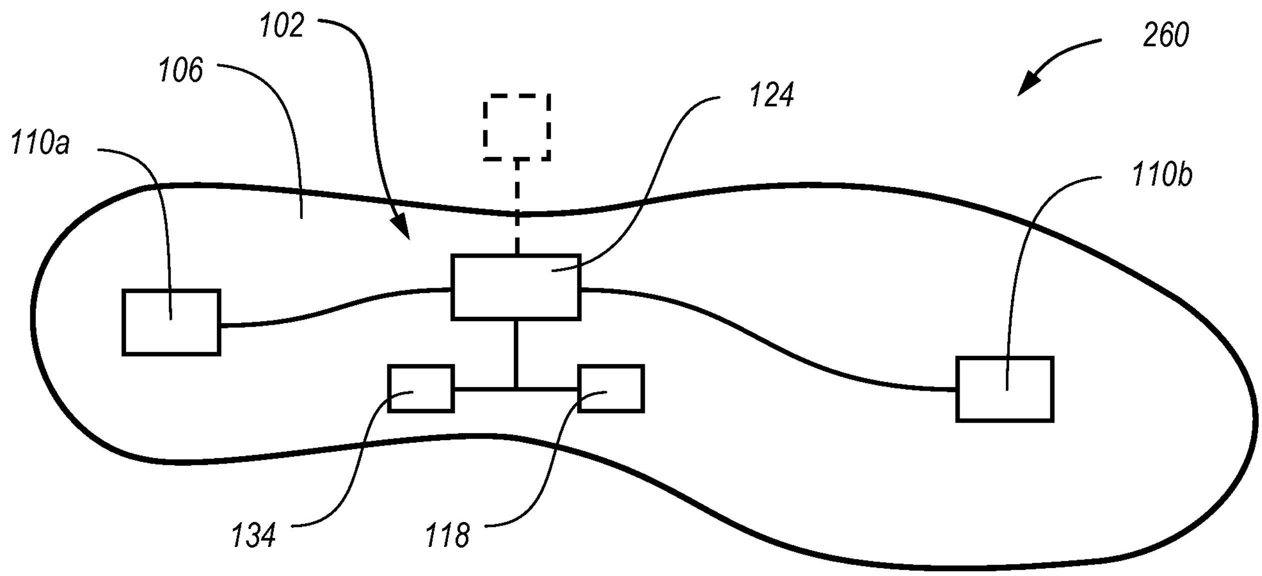
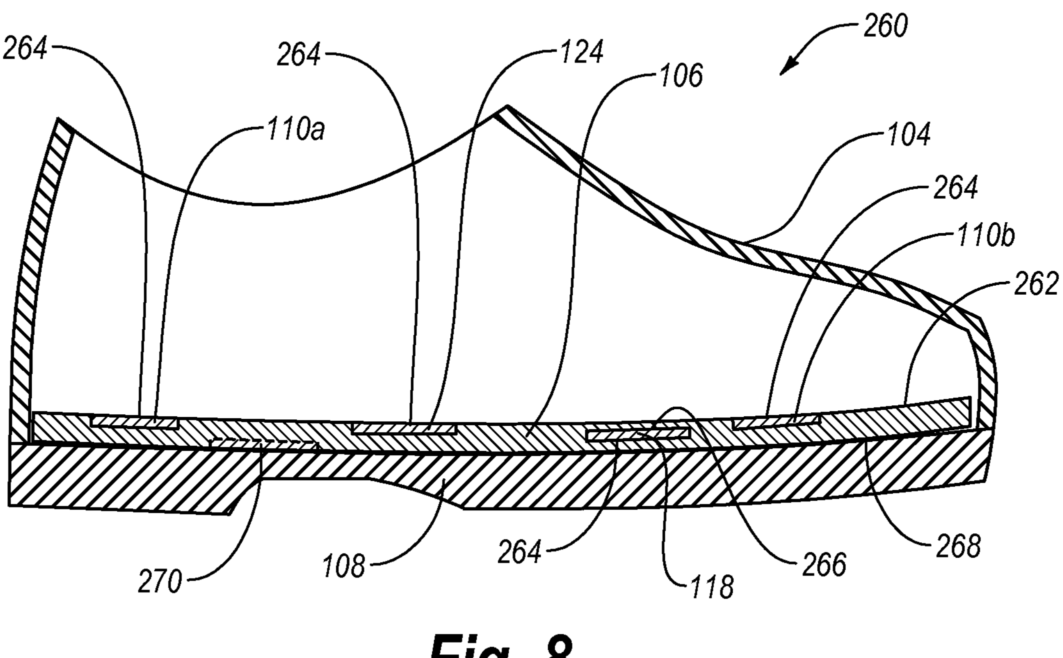

102
106
110a
260
124
110b
134
118

Fig. 7


264
264
124
106
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110a
104
264
110b
262
270
108
264
118
266
268

Fig. 8

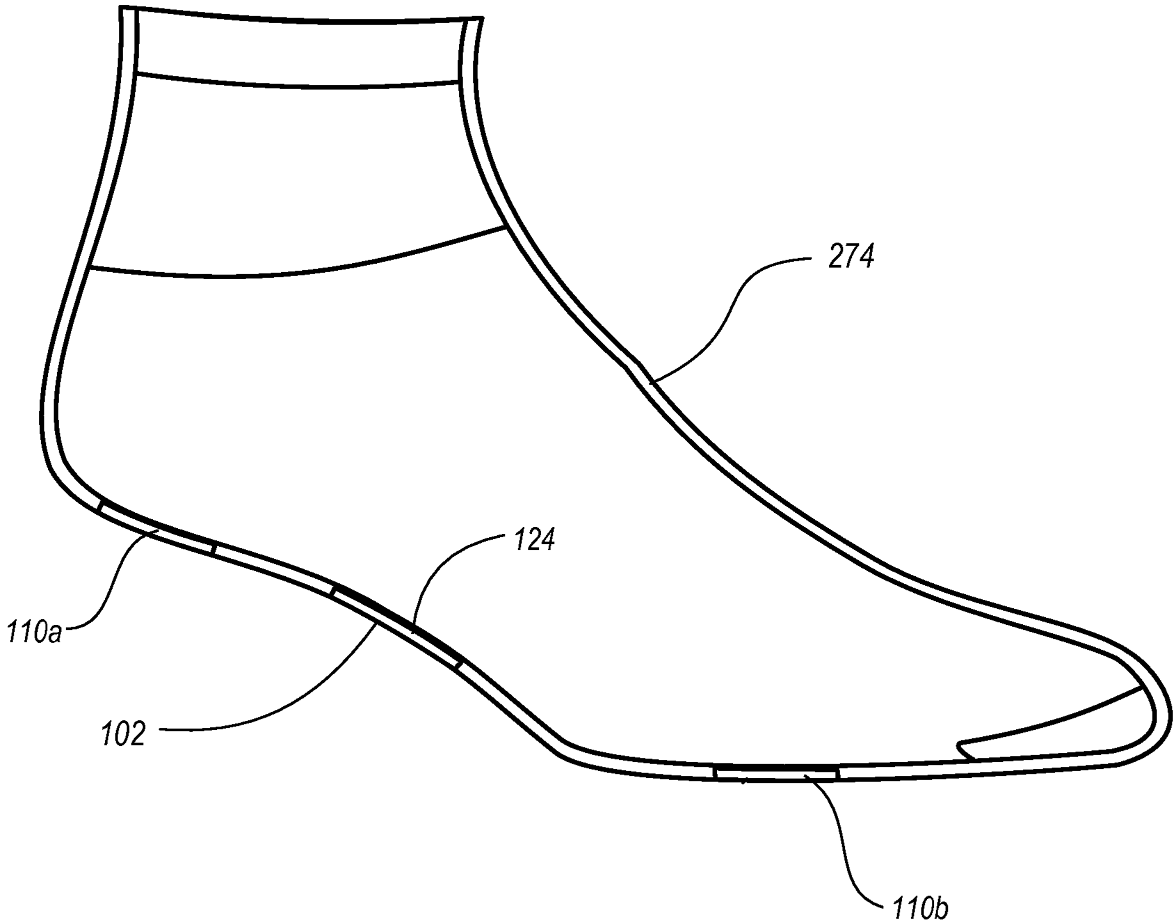


Fig. 9

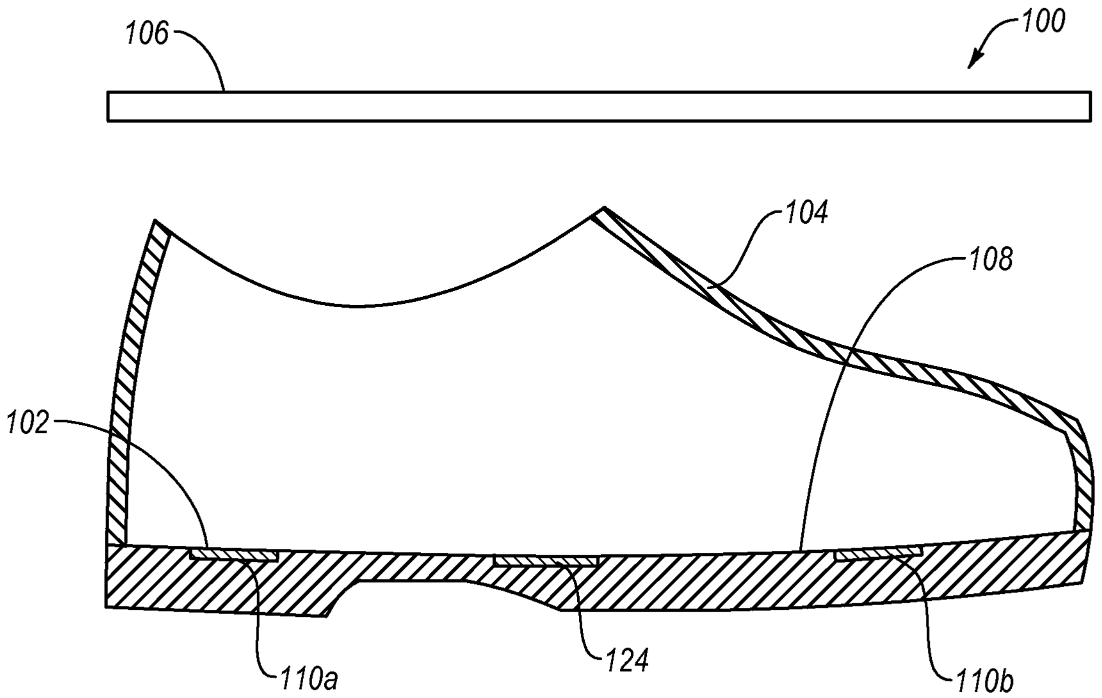


Fig. 10

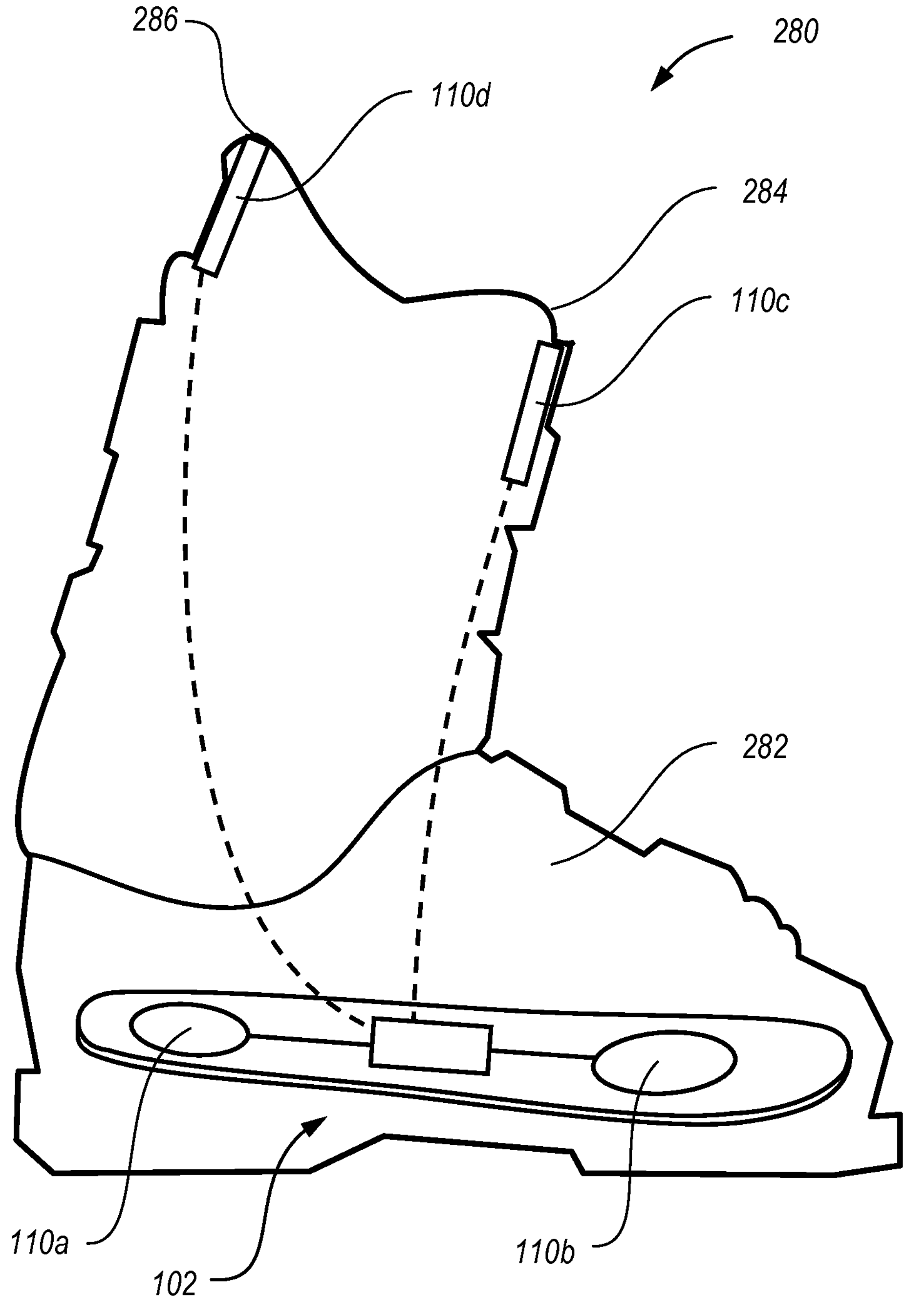


Fig. 11

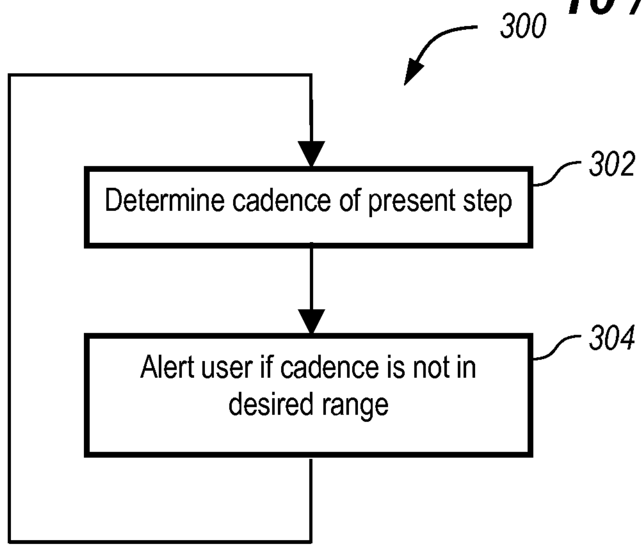

300
Determine cadence of present step
302
Alert user if cadence is not in desired range
304

Fig. 12

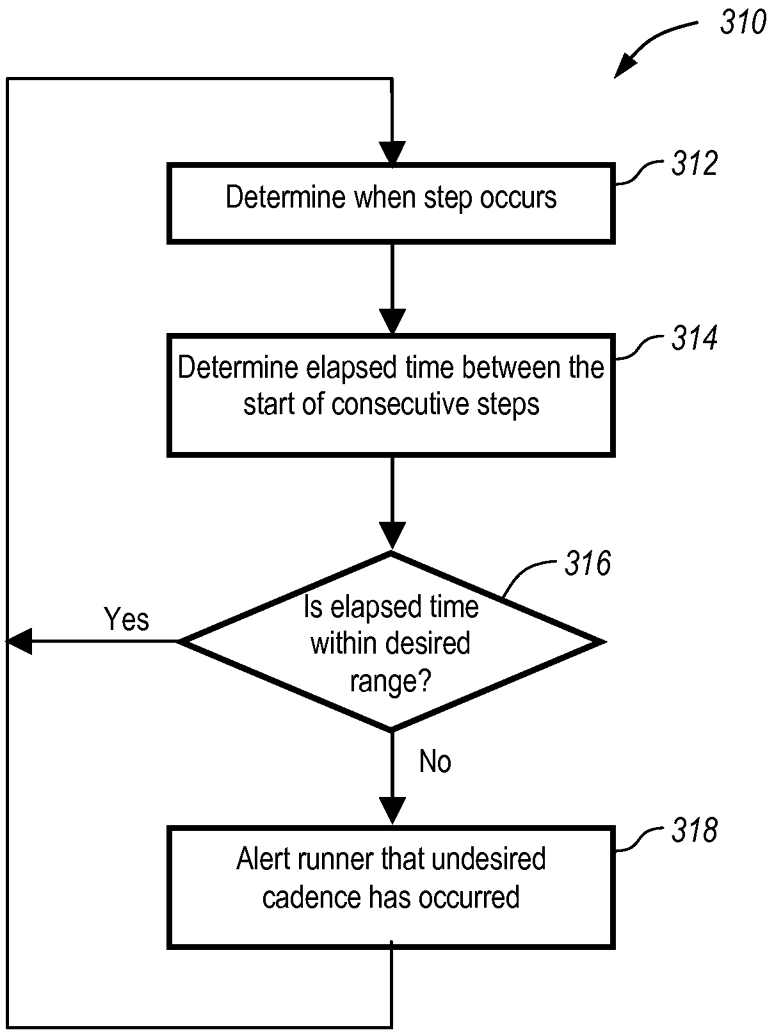

310
Determine when step occurs
312
Determine elapsed time between the start of consecutive steps
314
Is elapsed time within desired range?
316
Yes
No
Alert runner that undesired cadence has occurred
318

Fig. 13

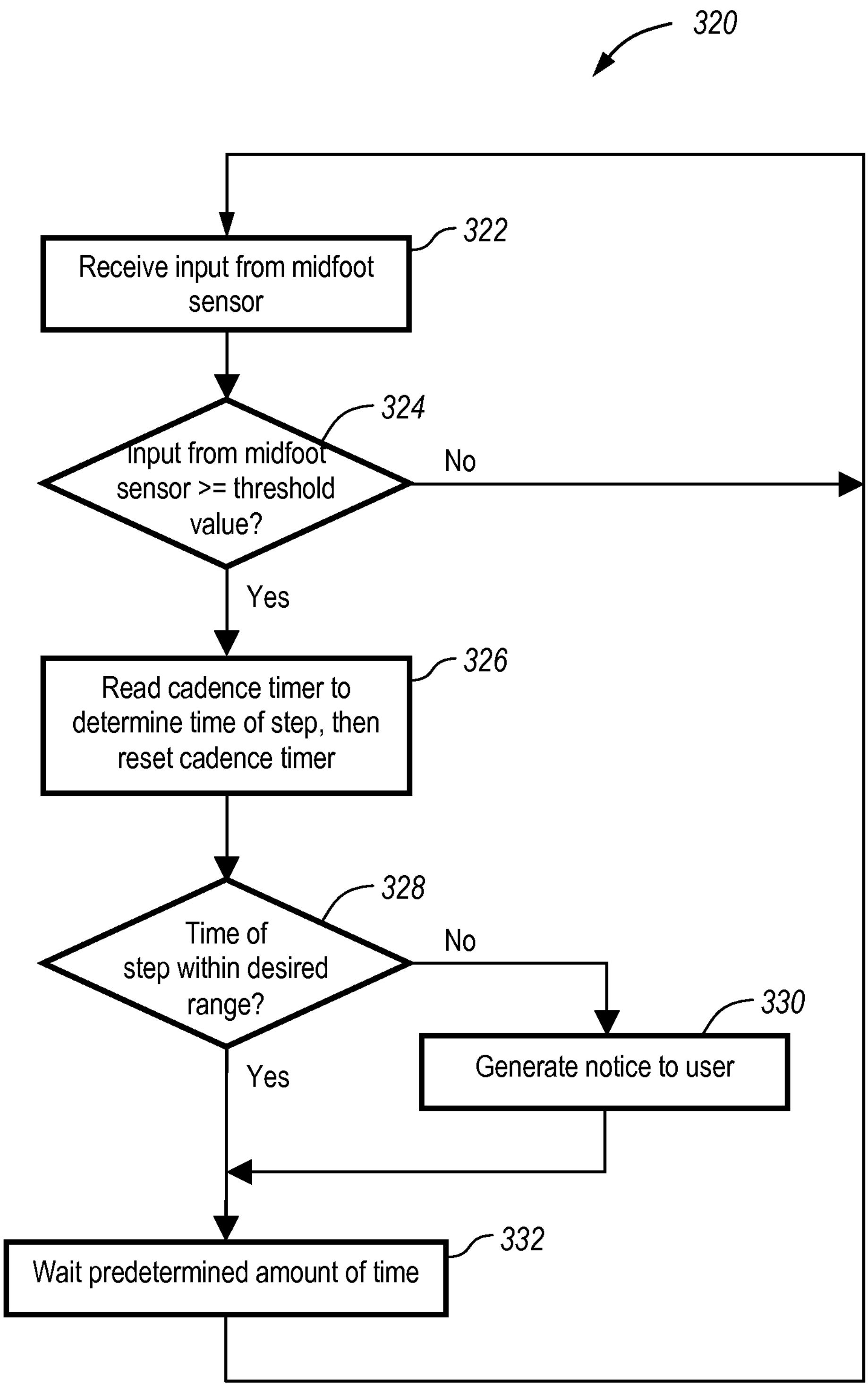

320
Receive input from midfoot sensor
322
Input from midfoot sensor >= threshold value?
324
No
Yes
Read cadence timer to determine time of step, then reset cadence timer
326
Time of step within desired range?
328
No
Yes
Generate notice to user
330
Wait predetermined amount of time
332

Fig. 14

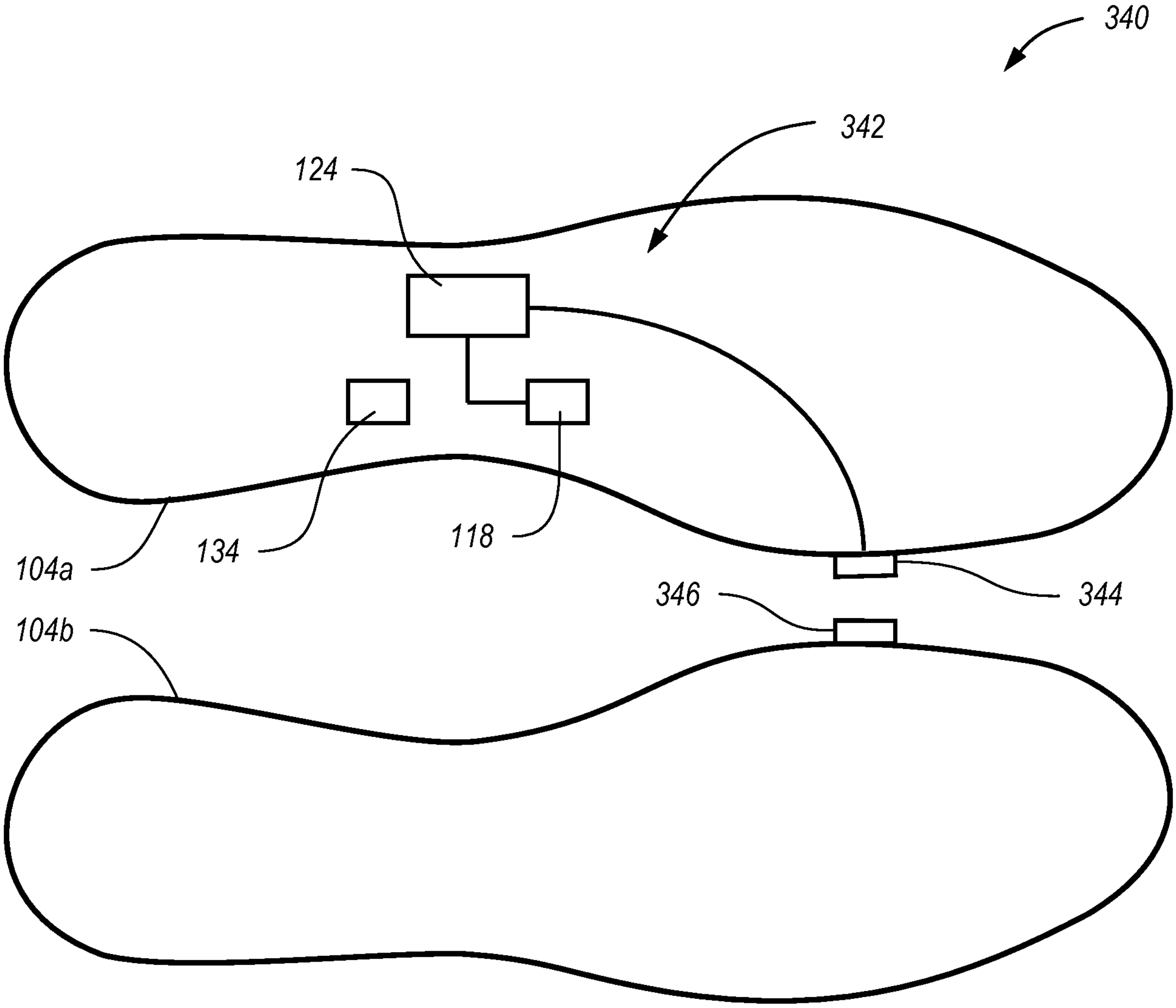
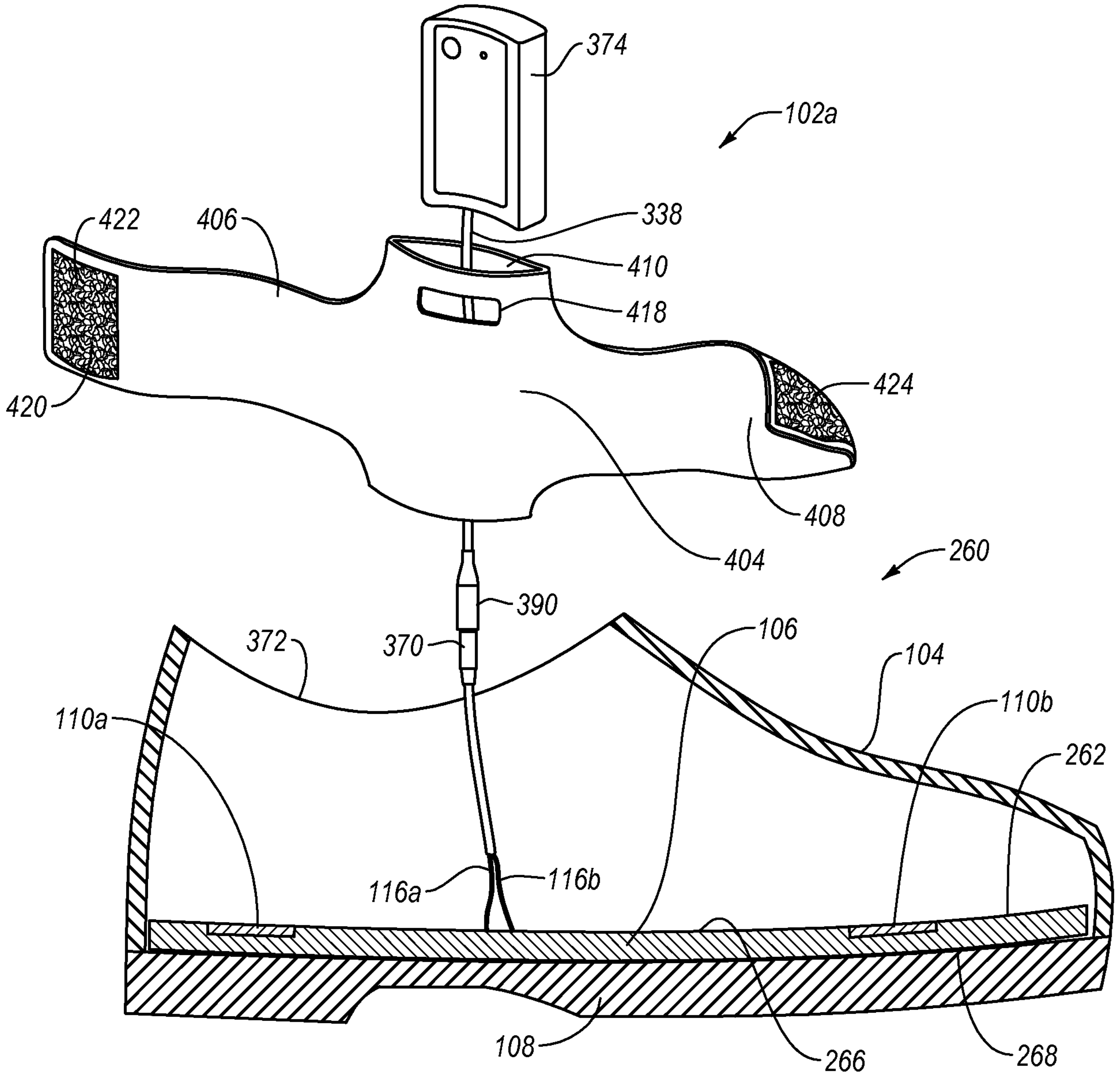


Fig. 15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102a
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110a
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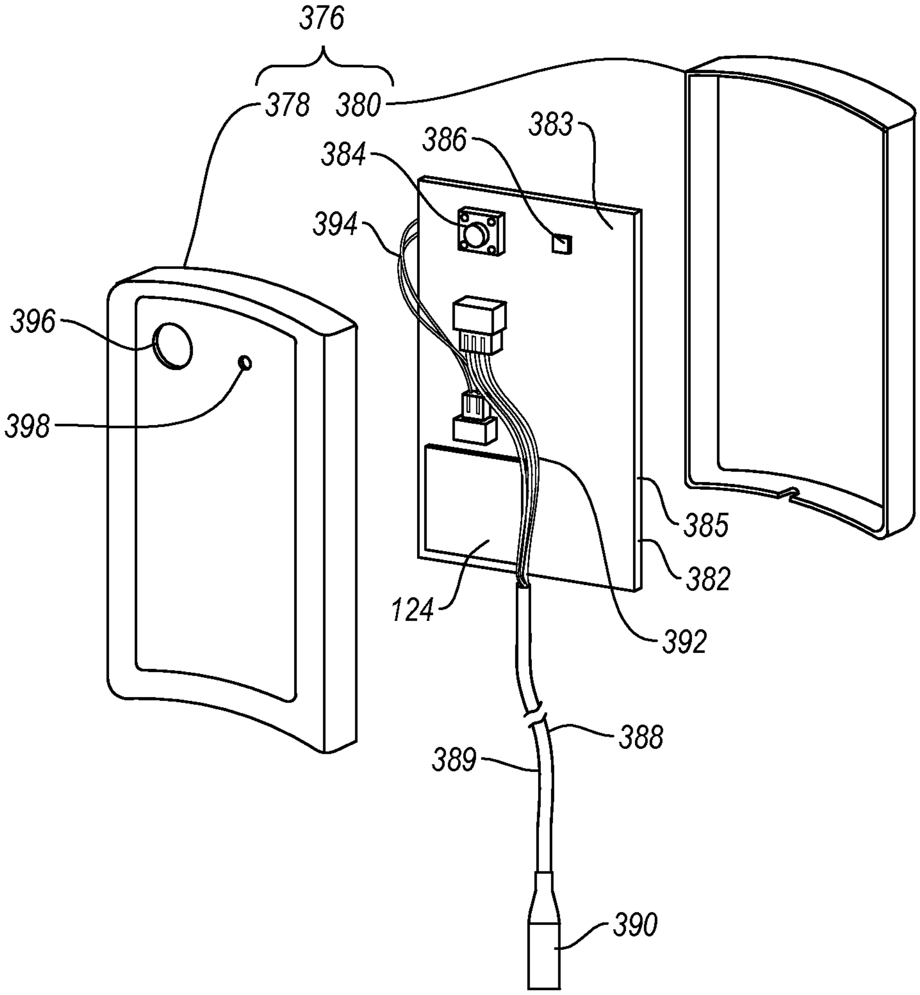
116b
108
266
268

Fig. 16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124
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388
389
390

Fig. 17

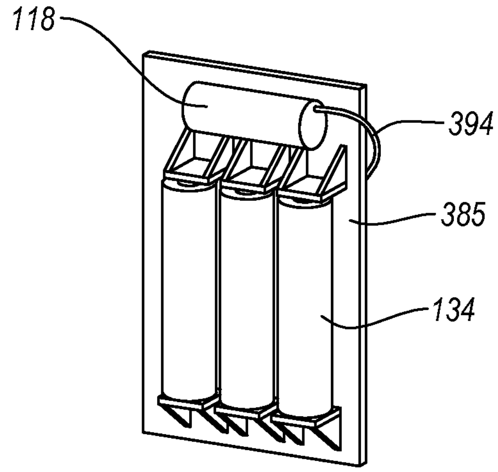
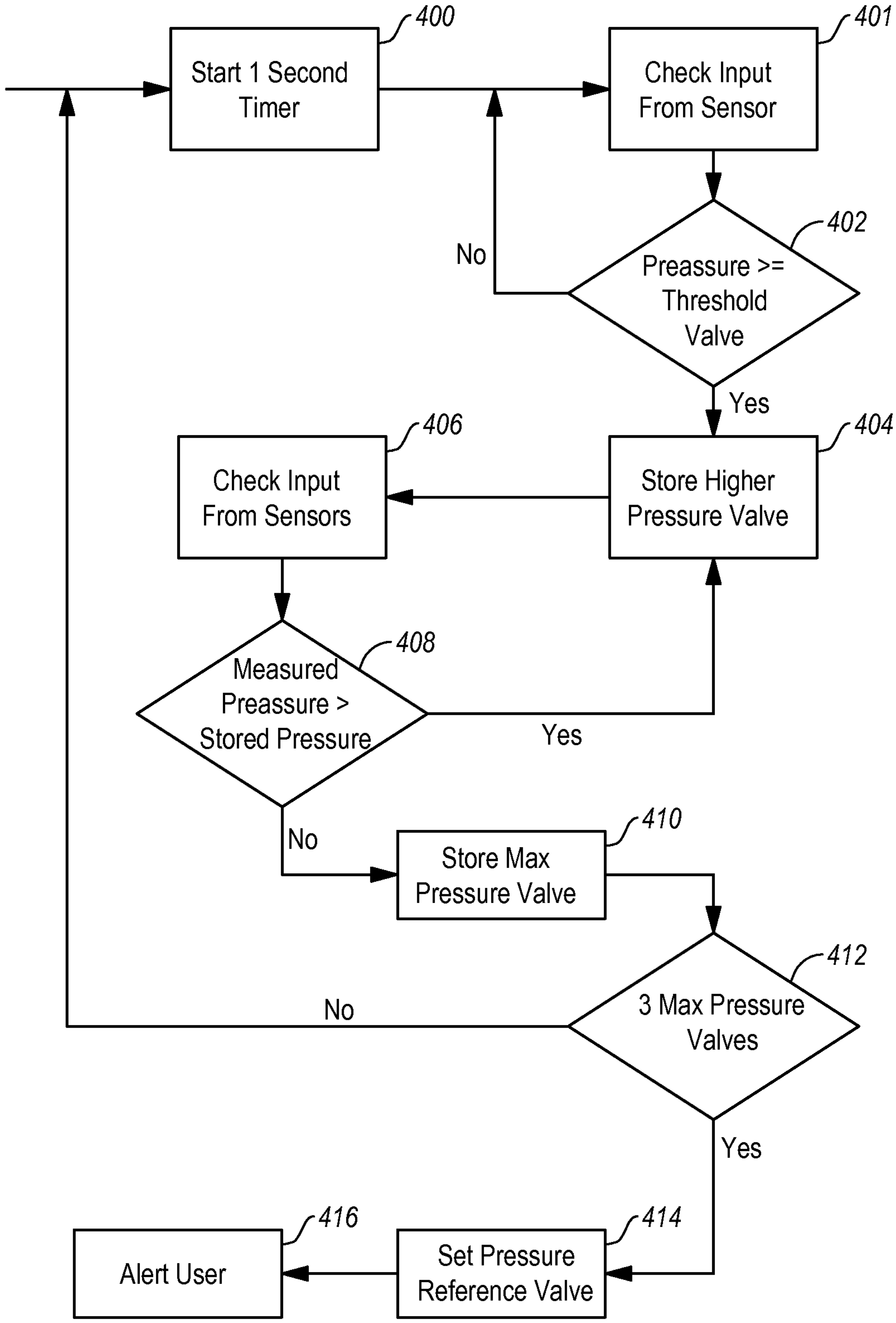

118
394
385
134

Fig. 18



Start 1 Second Timer
400
Check Input From Sensor
401
Preassure >= Threshold Valve
402
No
Yes
Store Higher Pressure Valve
404
Check Input From Sensors
406
Measured Preassure > Stored Pressure
408
Yes
No
Store Max Pressure Valve
410
3 Max Pressure Valves
412
No
Yes
Set Pressure Reference Valve
414
Alert User
416

Fig. 19

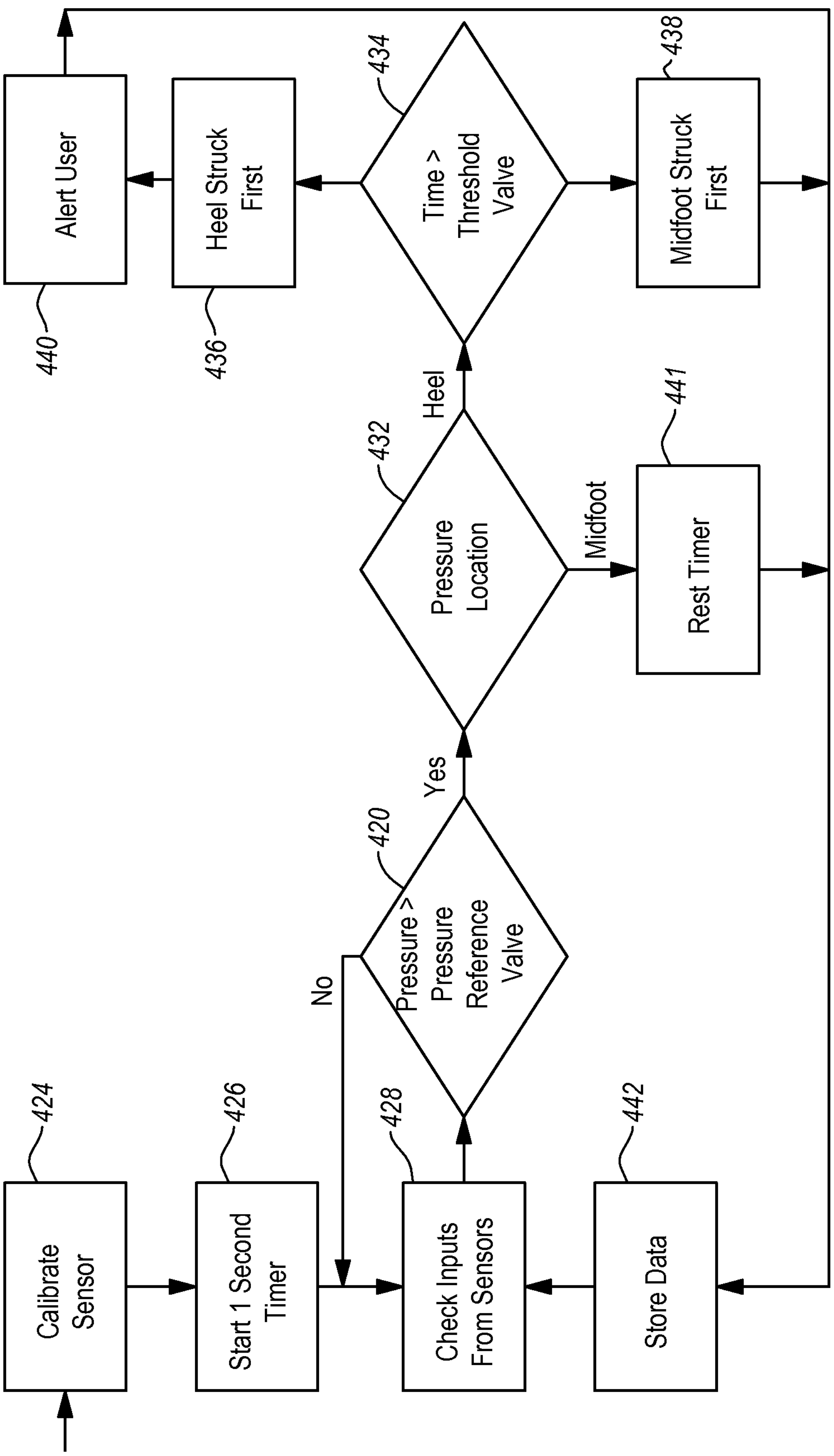

Calibrate Sensor
424
Start 1 Second Timer
426
Check Inputs From Sensors
428
Pressure > Pressure Reference Valve
420
No
Yes
Pressure Location
432
Heel
Midfoot
Rest Timer
441
Time > Threshold Valve
434
Heel Struck First
436
Midfoot Struck First
438
Alert User
440
Store Data
442

Fig. 20

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/020689

A. CLASSIFICATION OF SUBJECT MATTER
INV. A43B3/00
ADD.

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)
A43B

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/066343 A1 (SANABRIA-HERNANDEZ LILLIAN [US]) 20 March 2008 (2008-03-20) paragraph [0044]; figures paragraph [0046] paragraph [0048] - paragraph [0049] paragraph [0004] -----	1-24
A	US 5 615 111 A (RASKAS ERIC J [US] ET AL) 25 March 1997 (1997-03-25) claims; figures -----	1-24
A	US 2010/115799 A1 (WELTER BRADY [US] ET AL) 13 May 2010 (2010-05-13) claims; figures -----	1-24

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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

"E" earlier application or patent but published on or after the international filing date

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 March 2013	09/04/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Gkionaki, Angeliki

2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/020689

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

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

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

2. ☒ Claims Nos.: 25-30
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

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

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

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

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

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

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

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

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 25-30

In view of the number of independent claim (4 independent claims) and also the wording of the claims presently on file, which render it difficult, if not impossible, to determine the matter for which protection is sought, the present application fails to comply with the clarity and conciseness requirements of Article 6 PCT (see also Rule 6.1(a) PCT) to such an extent that a meaningful search is impossible. In the present case and prima facie, the claimed subject-matters are so numerous and different that they simply preclude the detailed analysis necessary to come to a firm conclusion regarding to the essential technical features of the invention and also the unity of the present application. Consequently, the search has been carried out for those parts of the application which do appear to be clear (and concise), namely independent claim 1 (apparatus claim), independent claim 17 (method) and dependent claims 2-16 and 18-24.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.2), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2013/020689

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008066343 A1	20-03-2008	US 2008066343 A1	20-03-2008
		US 2011265344 A1	03-11-2011
US 5615111 A	25-03-1997	NONE	
US 2010115799 A1	13-05-2010	NONE	