US009908001B2

(12) **United States Patent**
Dibenedetto et al.

(10) **Patent No.: US 9,908,001 B2**
(45) **Date of Patent: Mar. 6, 2018**

(54) **PORTABLE FITNESS MONITORING SYSTEMS WITH DISPLAYS AND APPLICATIONS THEREOF**

(71) Applicant: **adidas AG**, Herzogenaurach (DE)

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(73) Assignee: **adidas AG**, Herzogenaurach (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/409,597**

(22) Filed: **Jan. 19, 2017**

(65) **Prior Publication Data**

US 2017/0128782 A1 May 11, 2017

Related U.S. Application Data

(60) Continuation of application No. 14/278,639, filed on May 15, 2014, now Pat. No. 9,550,090, which is a (Continued)

(51) **Int. Cl.**
A63B 24/00 (2006.01)
A63B 71/06 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***A63B 24/0062*** (2013.01); ***A44B 1/00*** (2013.01); ***A44B 11/00*** (2013.01); ***A44B 13/00*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC A63B 24/0062; A63B 71/0622; A63B 71/0686; A63B 2024/0065;
(Continued)

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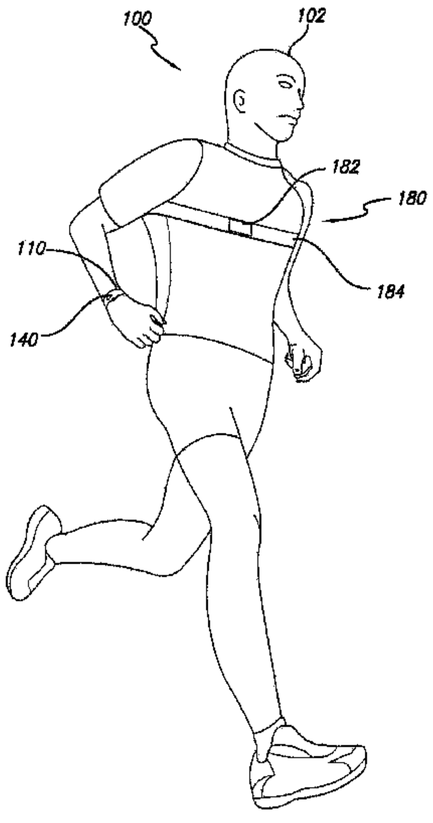
Notice of Allowance dated Sep. 27, 2012 in U.S. Appl. No. 13/328,425 to Oleson et al., filed Dec. 16, 2011.
(Continued)

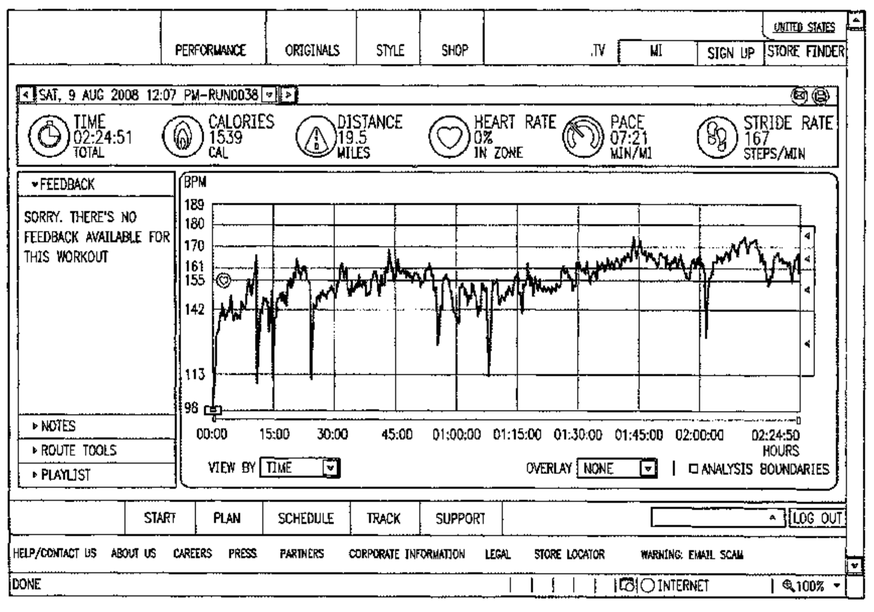
Primary Examiner — Glenn Richman
(74) *Attorney, Agent, or Firm* — Sterne, Kessler, Goldstein & Fox P.L.L.C.

(57) **ABSTRACT**

Portable fitness monitoring systems with displays, and applications thereof, are disclosed. In an embodiment, a method of providing performance feedback to an individual using a portable fitness monitoring device is provided. The method may include sensing performance parameter information during the physical activity, generating a first visual output that includes an indication of the intensity level that the individual should be performing at, and generating a second visual output that includes an indication of the intensity level that the individual is currently performing at.

13 Claims, 11 Drawing Sheets





Related U.S. Application Data

division of application No. 13/743,037, filed on Jan. 16, 2013, now Pat. No. 8,801,577, which is a continuation of application No. 13/328,425, filed on Dec. 16, 2011, now Pat. No. 8,360,936, which is a continuation of application No. 12/467,948, filed on May 18, 2009, now Pat. No. 8,105,208.

(51) **Int. Cl.**

A44C 5/14	(2006.01)
A44C 5/00	(2006.01)
A44B 18/00	(2006.01)
A44B 17/00	(2006.01)
A44B 1/00	(2006.01)
A44B 11/00	(2006.01)
A44B 99/00	(2010.01)
A44B 13/00	(2006.01)

(52) **U.S. Cl.**

CPC ***A44B 17/00*** (2013.01); ***A44B 18/00*** (2013.01); ***A44B 99/00*** (2013.01); ***A44C 5/0007*** (2013.01); ***A44C 5/14*** (2013.01); ***A63B 71/0622*** (2013.01); ***A63B 71/0686*** (2013.01); *A63B 2024/0065* (2013.01); *A63B 2071/0625* (2013.01); *A63B 2071/0661* (2013.01); *A63B 2071/0663* (2013.01); *A63B 2220/20* (2013.01); *A63B 2220/62* (2013.01); *A63B 2225/20* (2013.01); *A63B 2225/50* (2013.01); *A63B 2230/06* (2013.01); *A63B 2230/75* (2013.01)

(58) **Field of Classification Search**

CPC .. A63B 2071/00661; A63B 2071/0663; A63B 2071/0625; A63B 2225/20; A63B 2225/50; A63B 2225/223; A63B 2225/06; A63B 2225/75; A63B 2220/62; A63B 2220/20; A44C 5/14; A44C 5/0007; A44B 18/00; A44B 17/00; A44B 1/00; A44B 11/00; A44B 99/00; A44B 13/00

See application file for complete search history.

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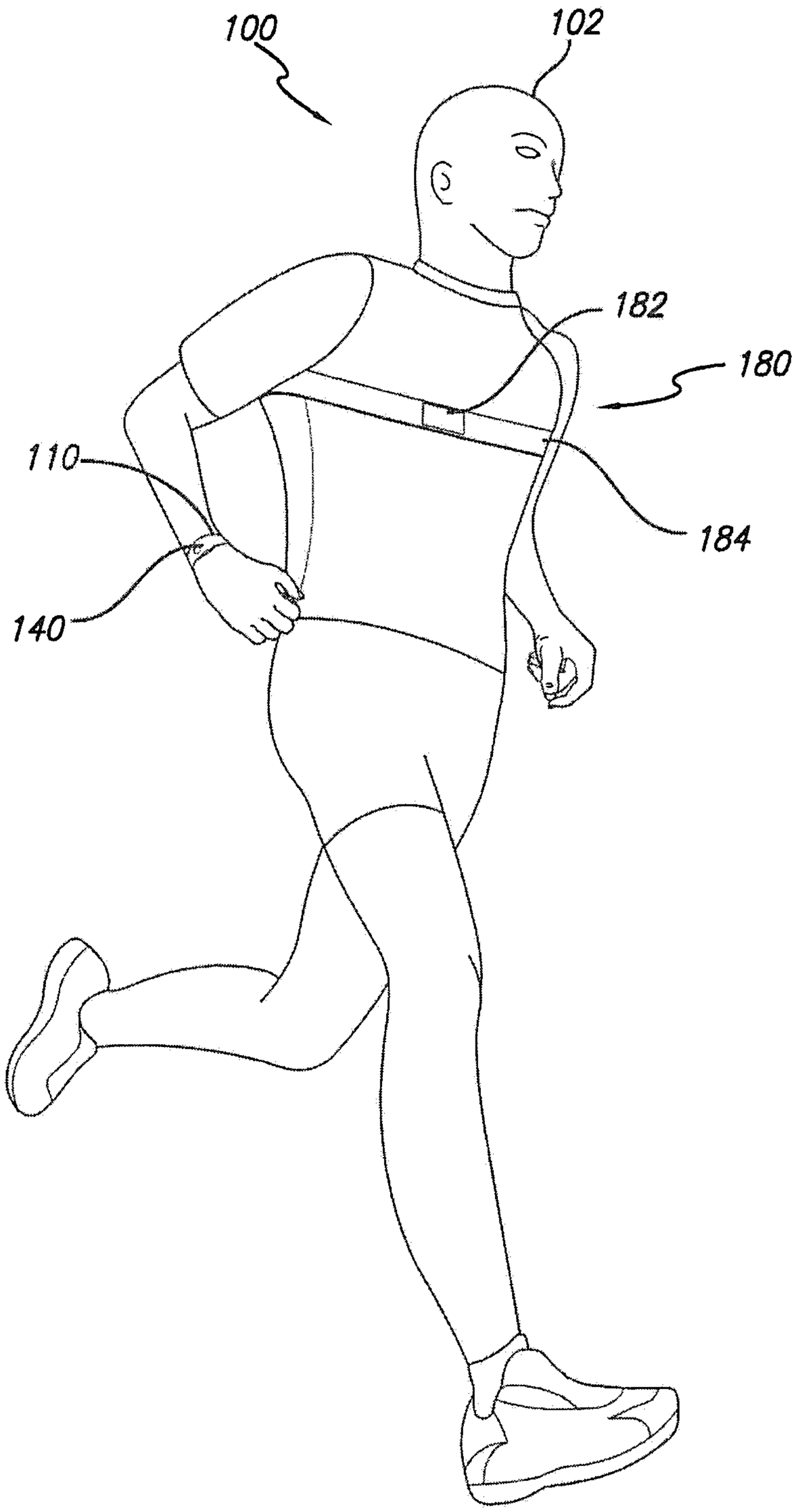


FIG. 1

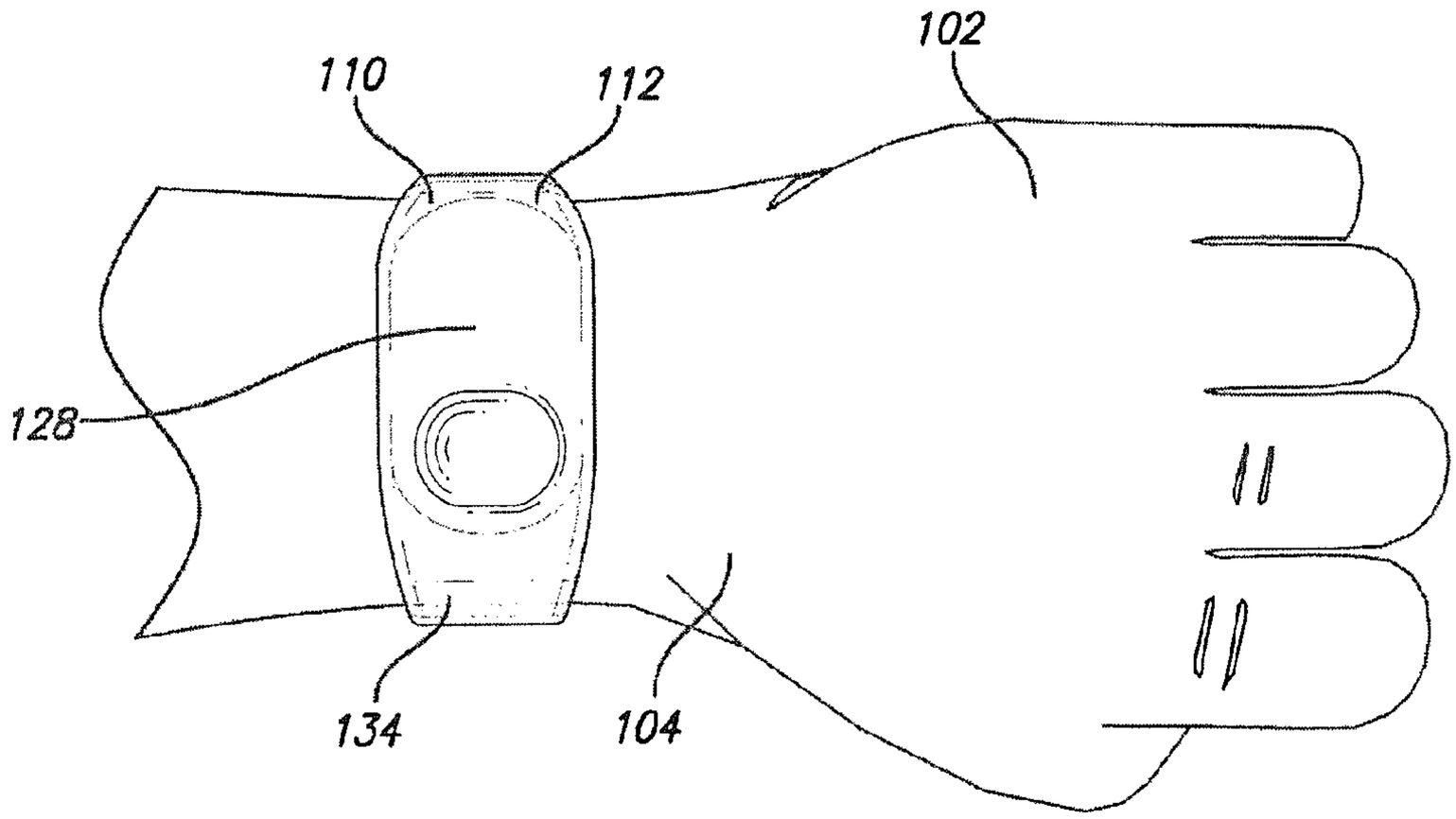


FIG. 2

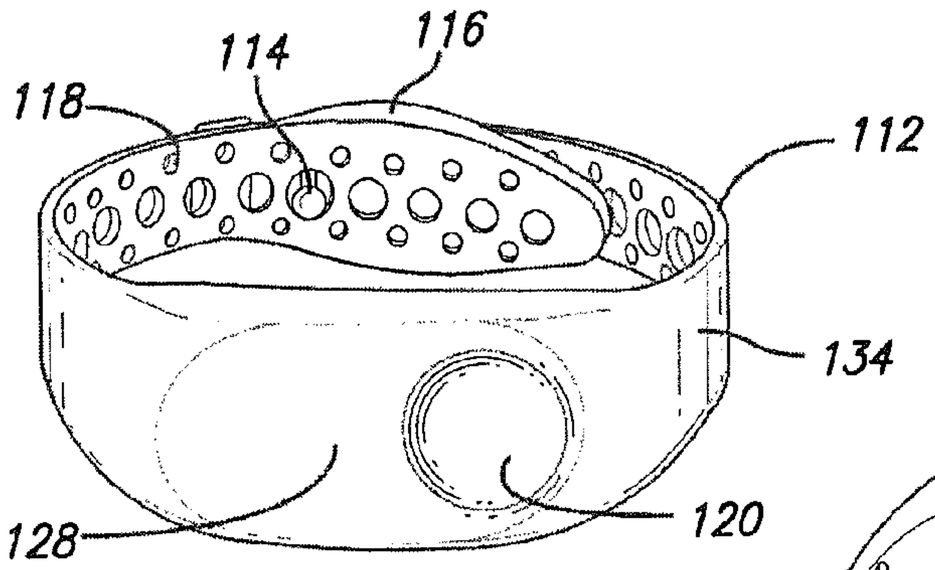


FIG. 3A

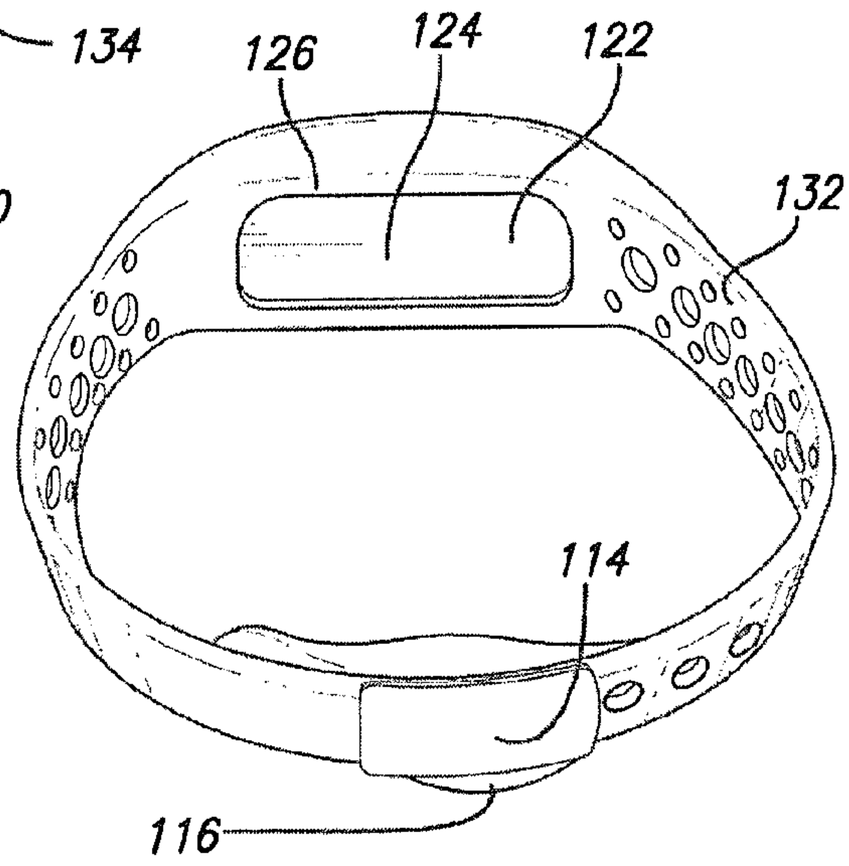


FIG. 3B

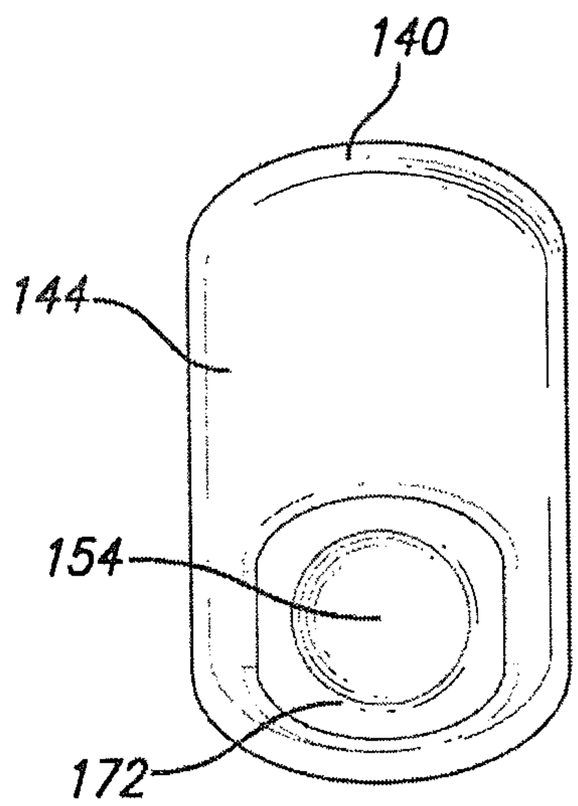


FIG. 4A

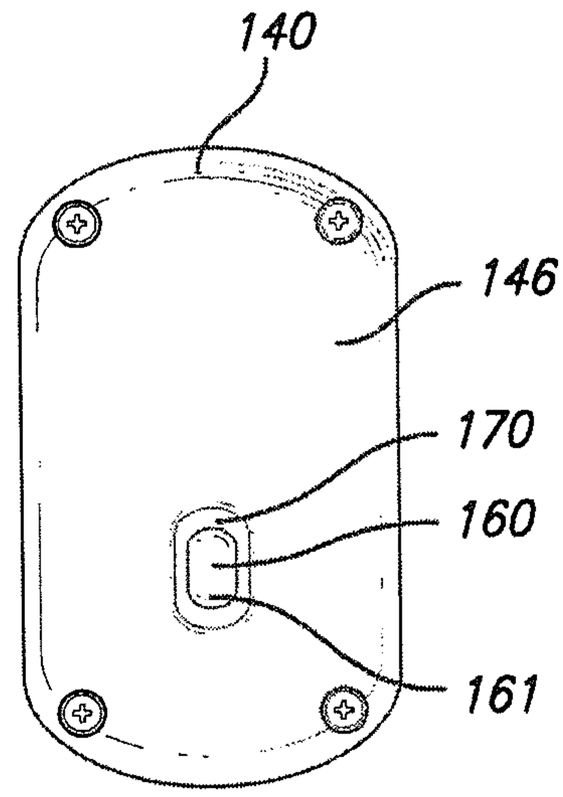


FIG. 4B

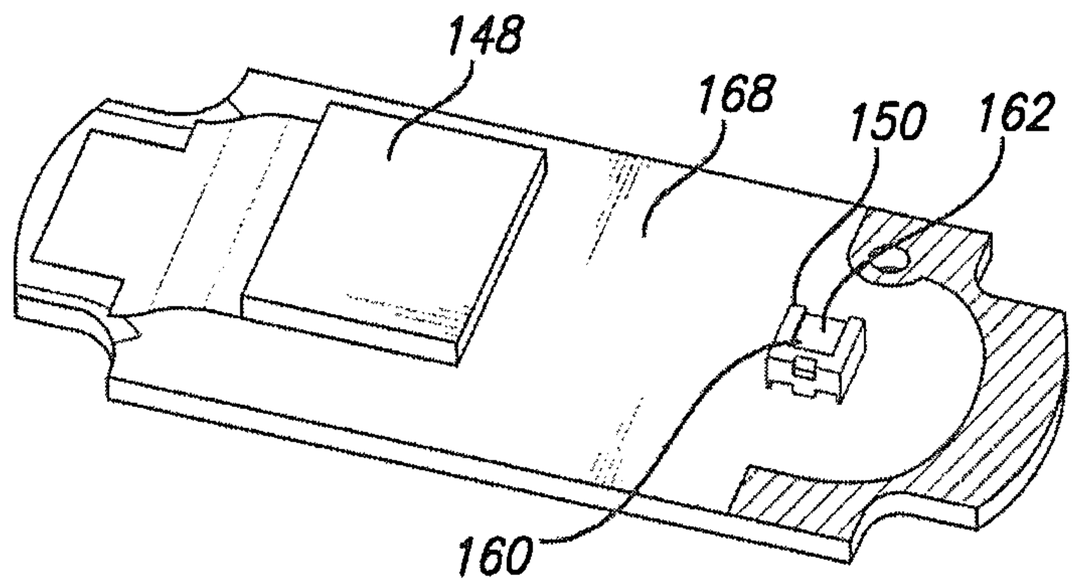


FIG. 5A

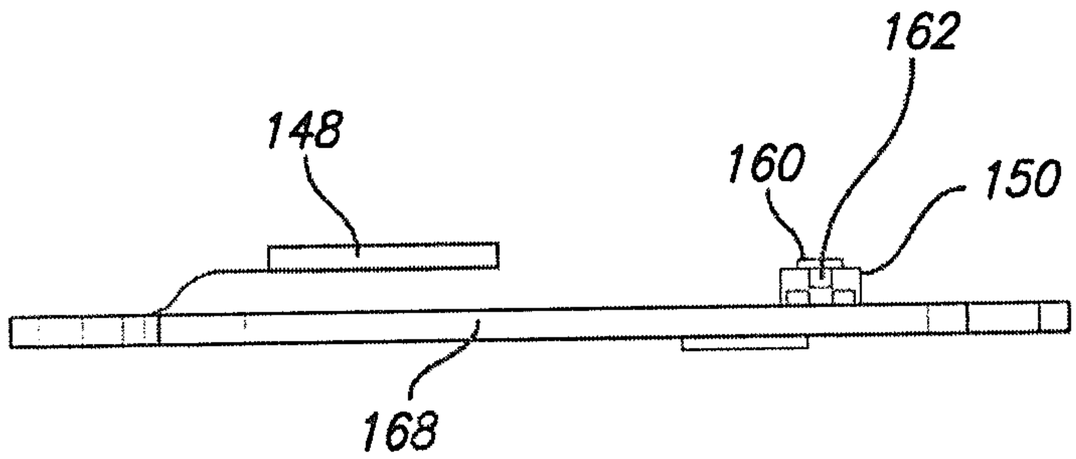


FIG. 5B

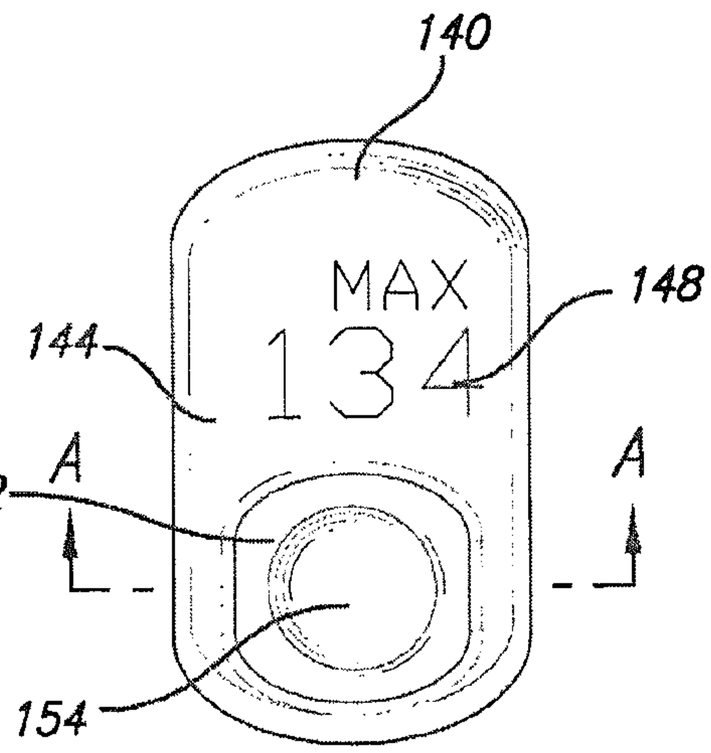


FIG. 6A

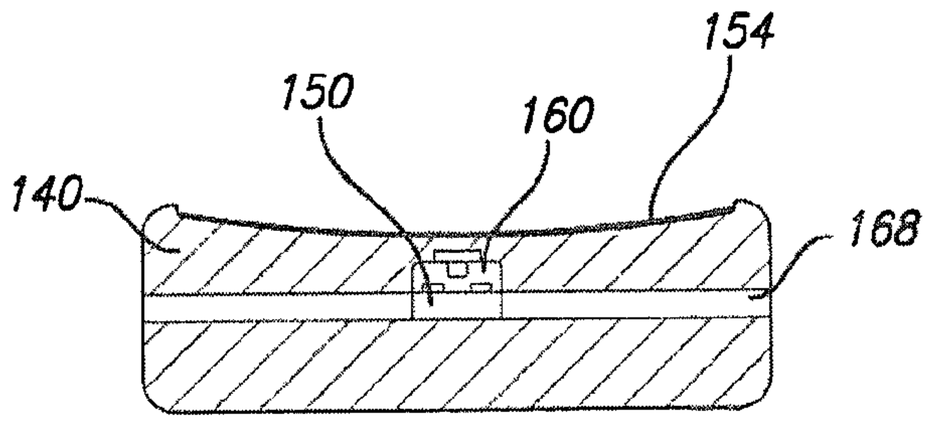


FIG. 6B

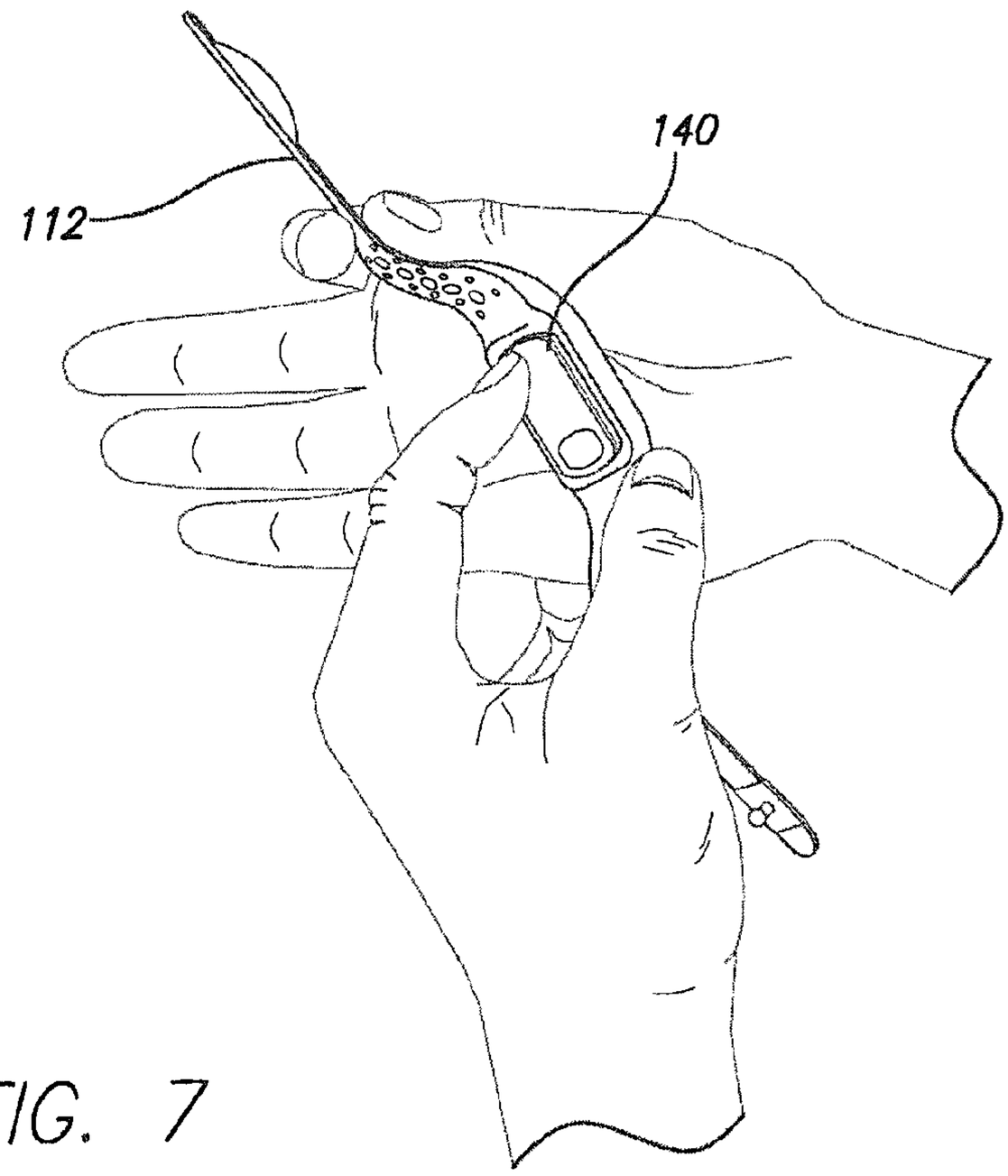


FIG. 7

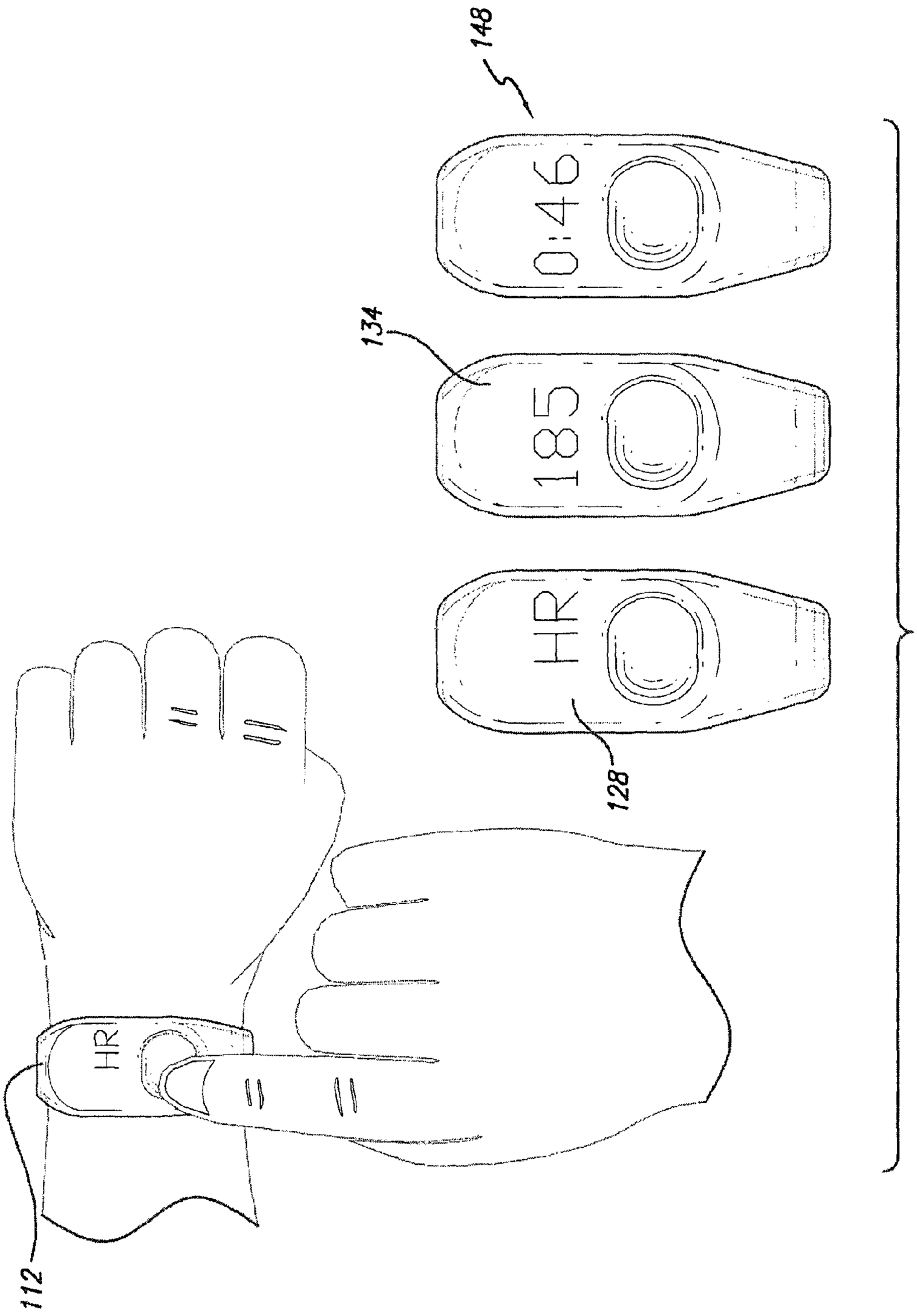


FIG. 8

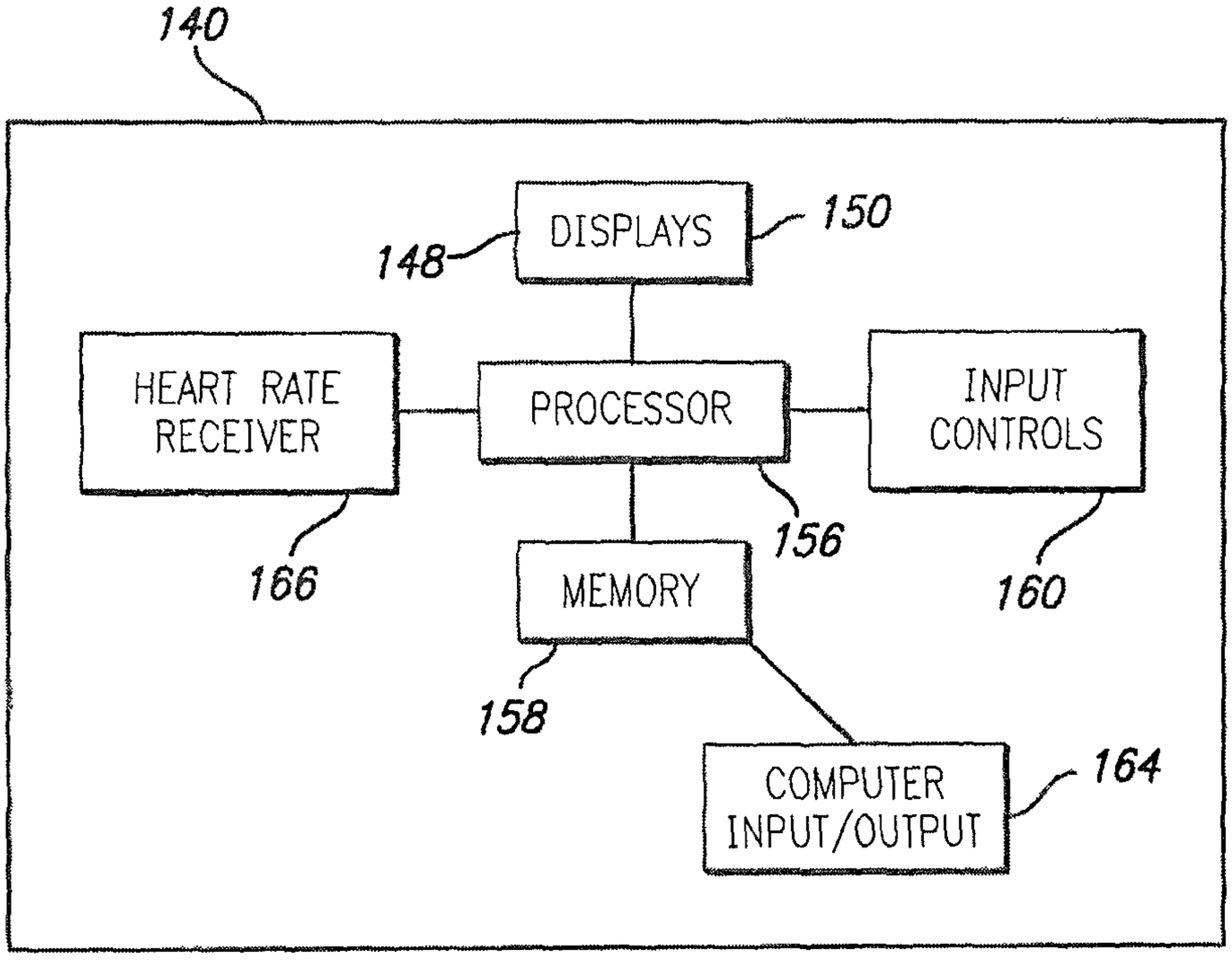

140
DISPLAYS
148
150
HEART RATE RECEIVER
PROCESSOR
INPUT CONTROLS
166
156
160
MEMORY
158
COMPUTER INPUT/OUTPUT
164

FIG. 9

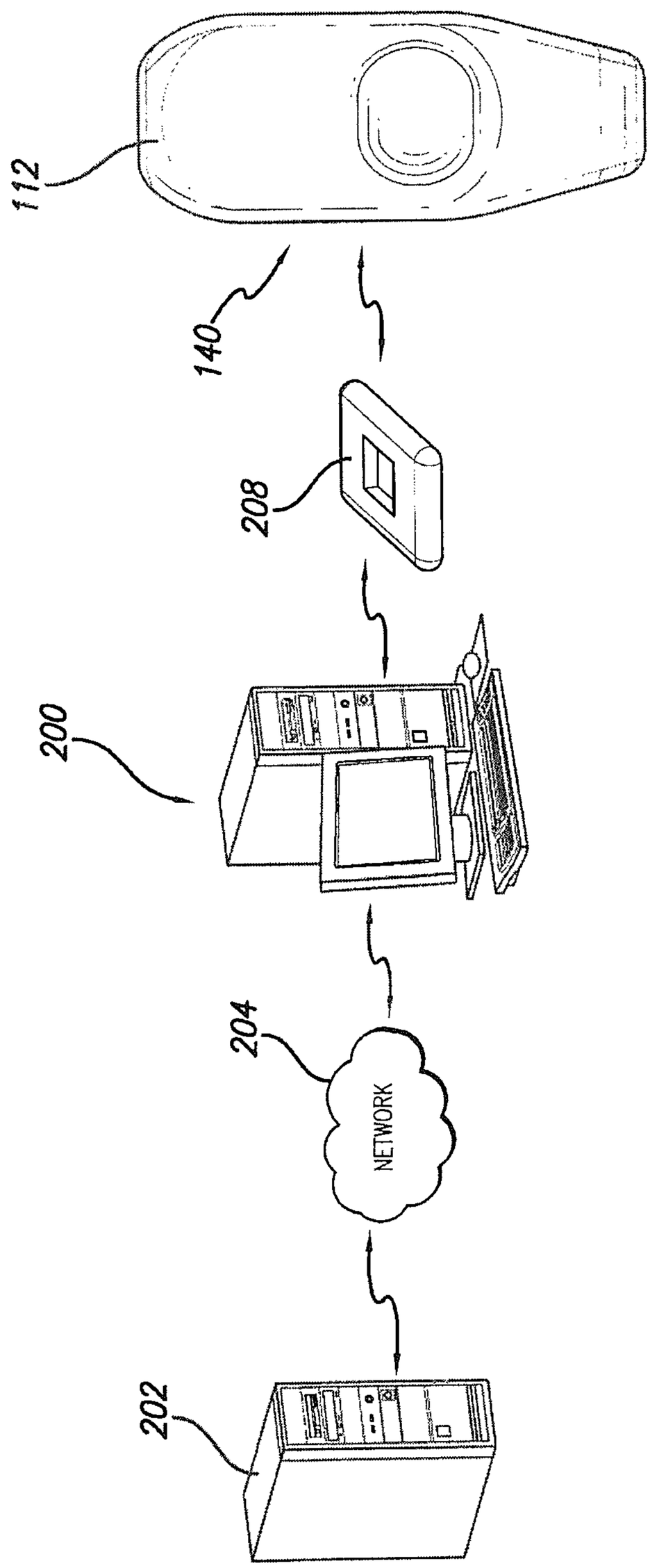


FIG. 10

ZONE	COLOR	% OF MAX HR
ENERGY	BLUE	65–75%
ENDURANCE	GREEN	75–85%
STRENGTH	YELLOW	85–90%
POWER	RED	90–95%

FIG. 11

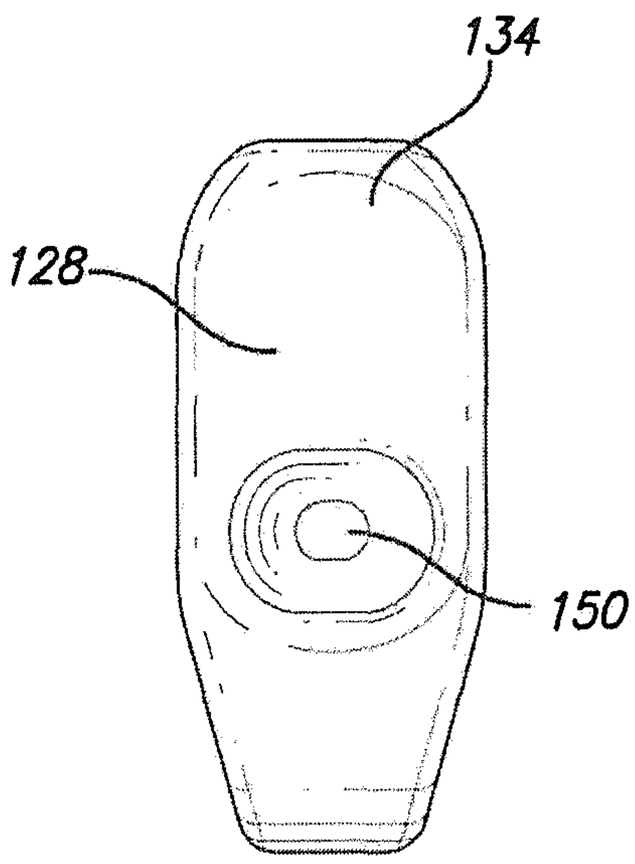


FIG. 12A

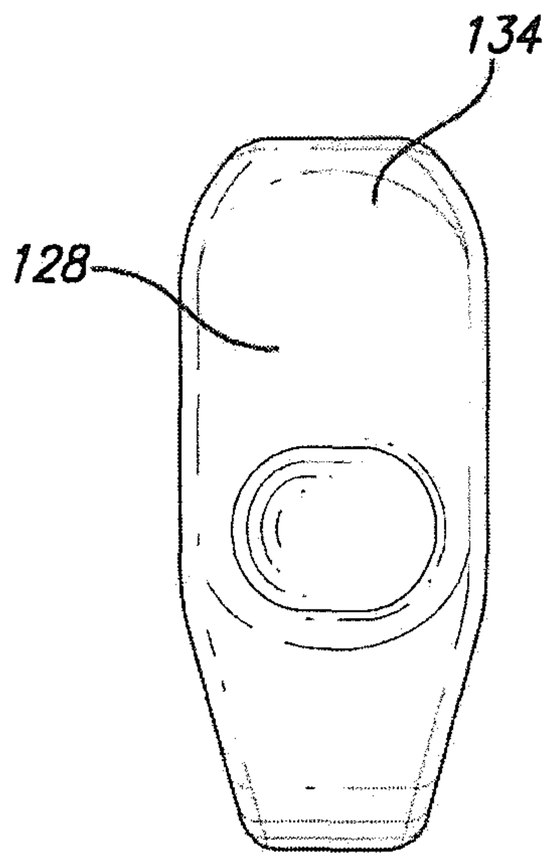


FIG. 12B

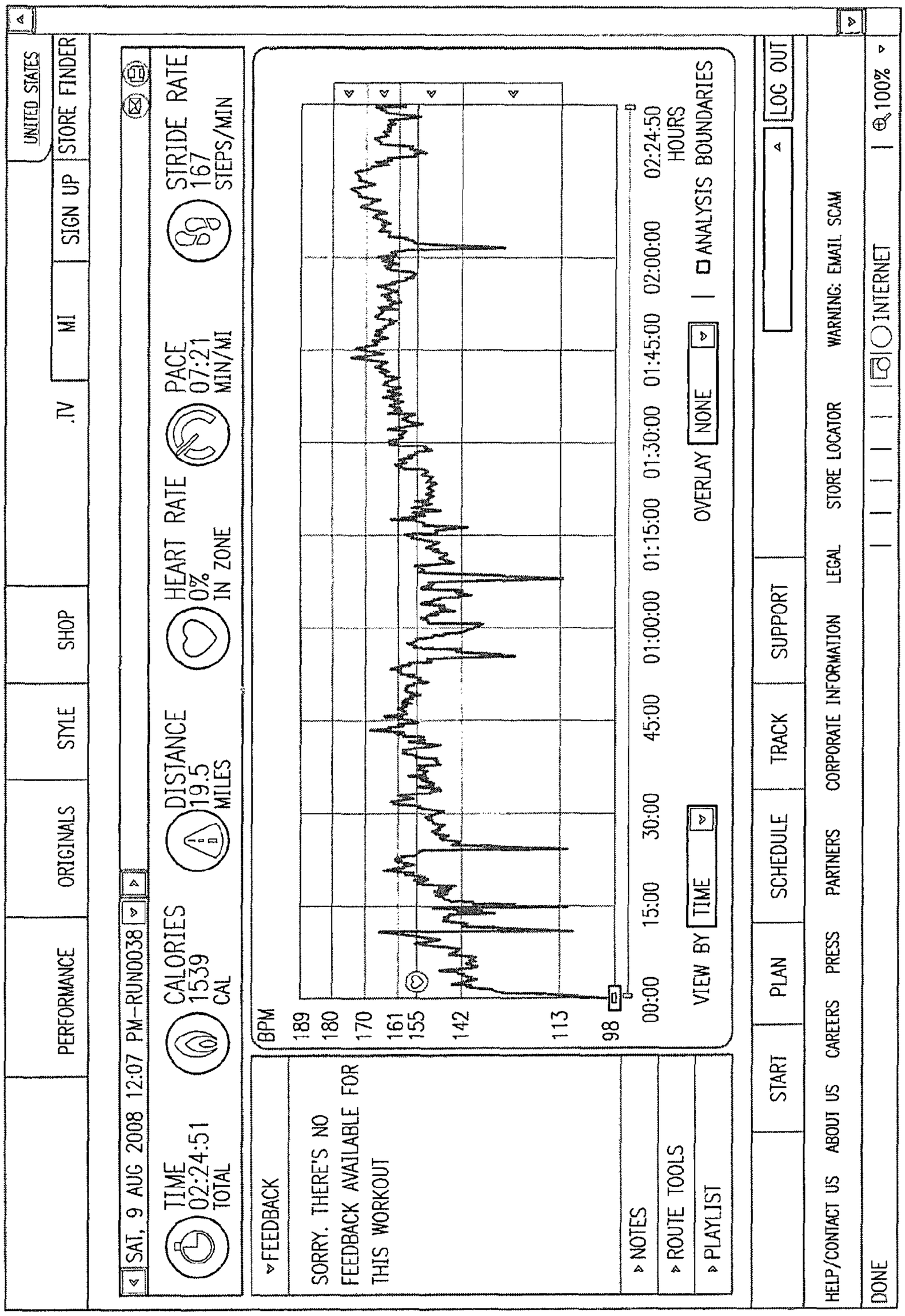

UNITED STATES
STORE FINDER
SIGN UP
PERFORMANCE
ORIGINALS
STYLE
SHOP
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MI
SAT, 9 AUG 2008 12:07 PM-RUN0038
STRIDE RATE
167
STEPS/MIN
DISTANCE
19.5
MILES
HEART RATE
0%
IN ZONE
PACE
07:21
MIN/MI
CALORIES
1539
CAL
TIME
02:24:51
TOTAL
BPM
189
180
170
161
155
142
113
98
02:00:00
02:24:50
HOURS
ANALYSIS BOUNDARIES
LOG OUT
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15:00
30:00
45:00
01:00:00
01:15:00
01:30:00
01:45:00
VIEW BY TIME
OVERLAY NONE
FEEDBACK
SORRY. THERE'S NO FEEDBACK AVAILABLE FOR THIS WORKOUT
NOTES
ROUTE TOOLS
PLAYLIST
PLAN
SCHEDULE
TRACK
SUPPORT
START
PARTNERS
CORPORATE INFORMATION
LEGAL
STORE LOCATOR
WARNING: EMAIL SCAM
INTERNET
100%
HELP/CONTACT US
ABOUT US
CAREERS
DONE

FIG. 13

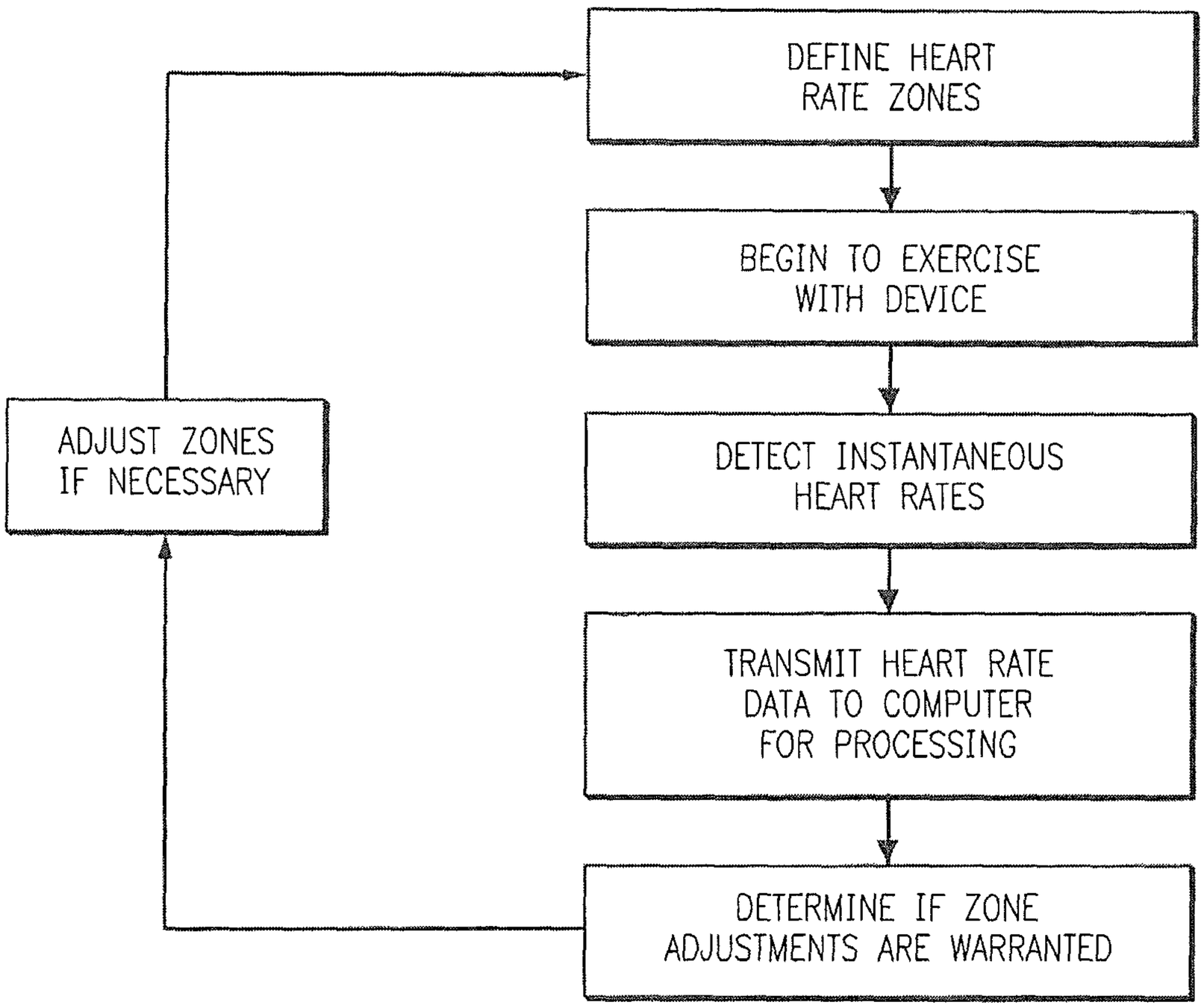

DEFINE HEART RATE ZONES
BEGIN TO EXERCISE WITH DEVICE
DETECT INSTANTANEOUS HEART RATES
TRANSMIT HEART RATE DATA TO COMPUTER FOR PROCESSING
DETERMINE IF ZONE ADJUSTMENTS ARE WARRANTED
ADJUST ZONES IF NECESSARY

FIG. 14

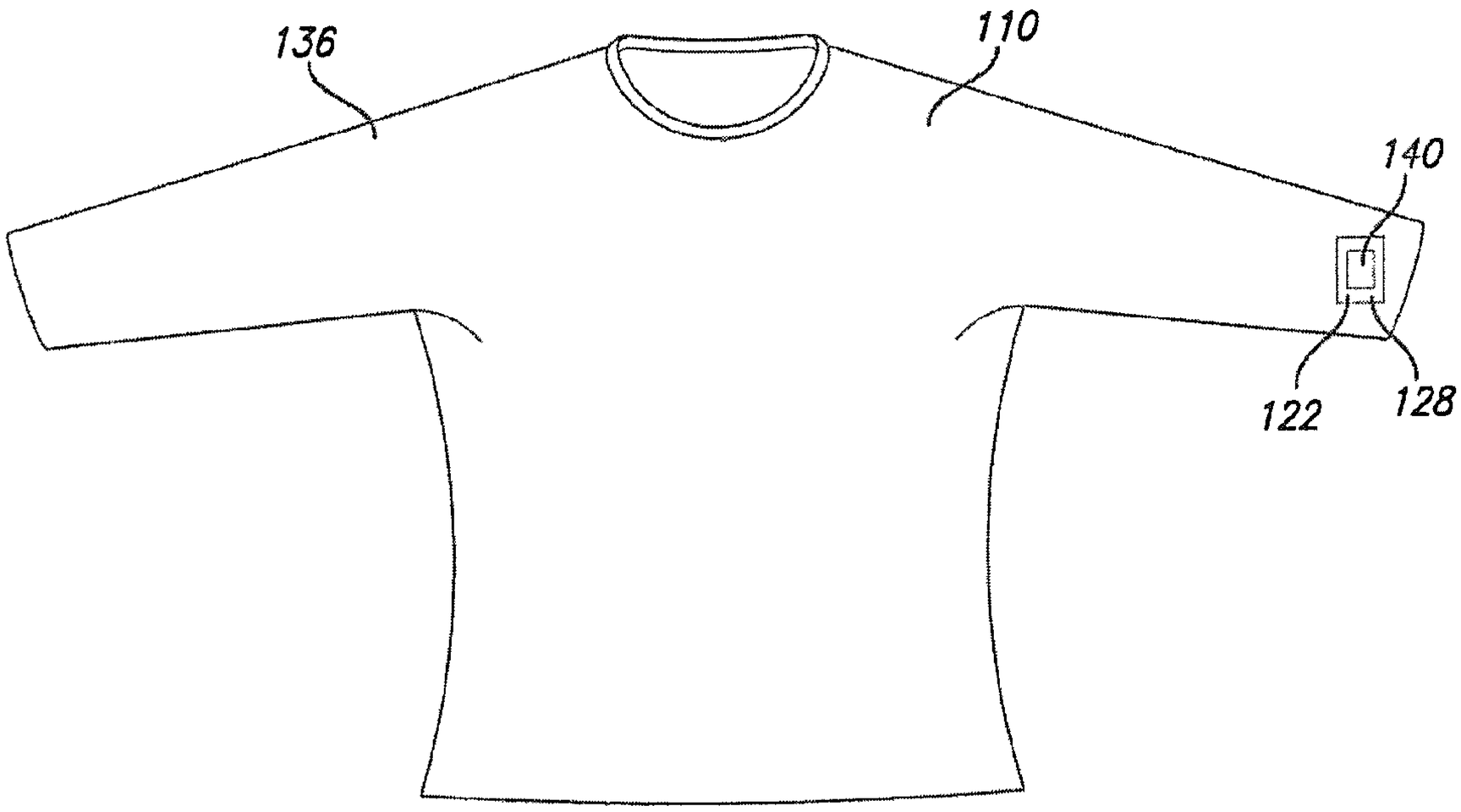


FIG. 15A

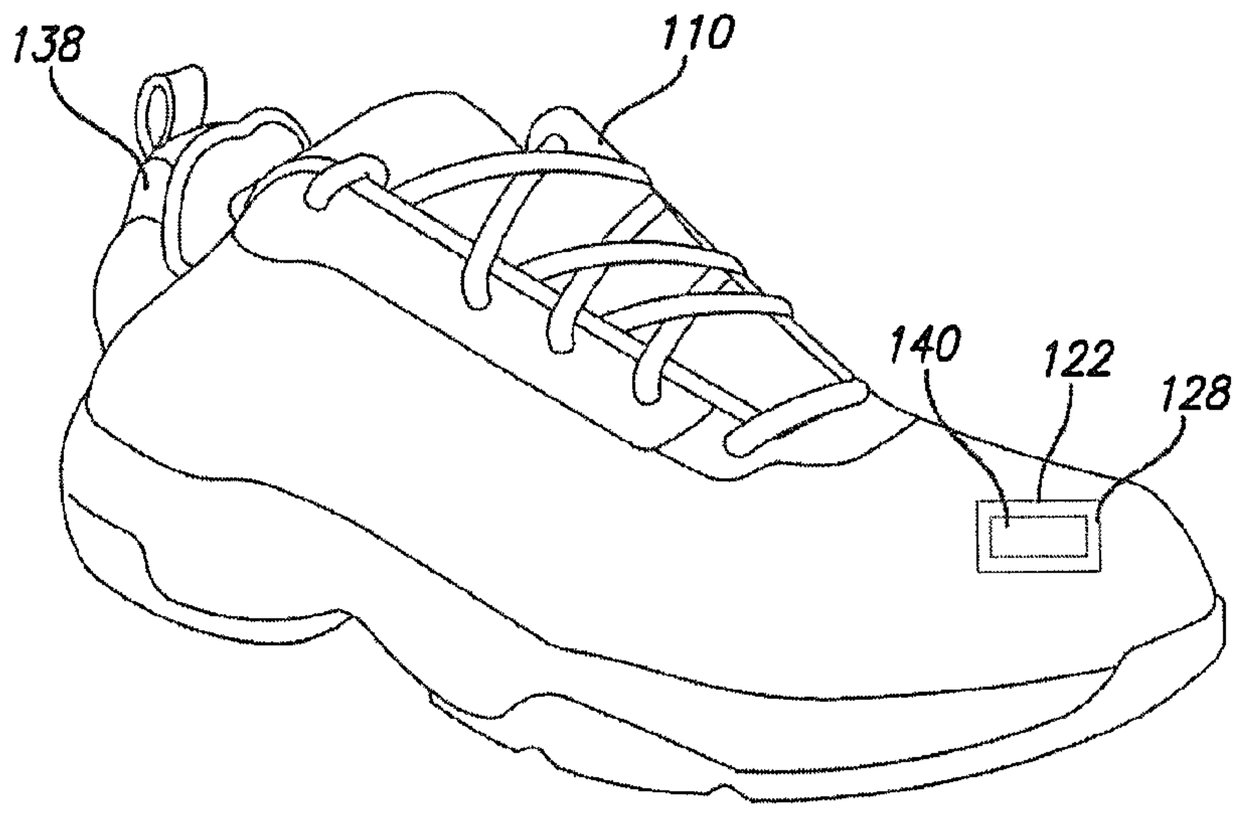


FIG. 15B

PORTABLE FITNESS MONITORING SYSTEMS WITH DISPLAYS AND APPLICATIONS THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of U.S. patent application Ser. No. 14/278,639, filed May 15, 2014, which is a divisional of U.S. patent application Ser. No. 13/743,037, filed Jan. 16, 2013, now U.S. Pat. No. 8,801,577, which is a continuation of U.S. patent application Ser. No. 13/328,425, filed Dec. 16, 2011, now U.S. Pat. No. 8,360,936, which is a continuation of U.S. patent application Ser. No. 12/467,948, filed May 18, 2009, now U.S. Pat. No. 8,105,208, each of which is incorporated herein by reference in its entirety.

This application is also related to commonly owned U.S. patent application Ser. No. 12/467,944, filed May 18, 2009, now U.S. Pat. No. 8,033,959, and commonly owned U.S. patent application Ser. No. 12/468,025, filed May 18, 2009, now U.S. Pat. No. 8,200,323, each of which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

The present invention generally relates to fitness monitoring systems. More particularly, the present invention relates to portable fitness monitoring systems with displays, and methods of providing performance feedback using a portable fitness monitoring device.

BACKGROUND OF THE INVENTION

Exercise is important to maintaining a healthy lifestyle and individual well-being. Accordingly, many individuals want to participate in an exercise program. The most successful exercise programs may be ones tailored to a fitness level of an individual and aimed at assisting the individual to achieve one or more specific fitness or exercise goals. Information about the individual's progress toward achieving their goals may be collected using sensors for measuring various physical and/or physiological parameters associated with the individual's physical activity.

Amateur and professional athletes alike have begun paying greater attention to specific heart rates (i.e. heart beats per minute) achieved during exercise, as recommended by their trainers and other programs. While in some cases it may not be critical that the exercising individual establish a precise heart rate, the individual may want to maintain their heart rate within desired ranges throughout their physical activity to achieve specific fitness goals. Technology has resulted in the development of portable heart rate monitors that can detect the individual's heart rate and provide a variety of outputs indicative thereof.

What is needed are new portable fitness monitoring systems that have displays with improved aesthetics and functionalities that enable the individual to exercise at intensities appropriate for their current fitness level and goals.

BRIEF SUMMARY OF THE INVENTION

In at least one embodiment, a method of providing performance feedback to an individual using a portable fitness monitoring device includes sensing performance parameter information during the physical activity, generating a first visual output that includes an indication of the intensity level that the individual should be performing at, and generating a second visual output that includes an indication of the intensity level that the individual is currently performing at.

In another embodiment, a method includes sensing performance parameter information during the physical activity, generating a first output that includes an indication of the intensity level that the individual should be performing at, and generating a second output that includes an indication of the intensity level that the individual is currently performing at.

In another embodiment, a method includes sensing performance parameter information during the physical activity, generating a first visual output that includes an indication of the intensity level that the individual should be performing at, generating a second visual output that includes an indication of the intensity level that the individual is currently performing at, and changing the second visual output in response to a change in the intensity level that the individual is currently performing at.

Further embodiments, features, and advantages of the present invention, as well as the structure and operation of the various embodiments of the present invention, are described in detail below with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS/FIGURES

The accompanying drawings, which are incorporated herein and form a part of the specification, illustrate the present invention by way of example, and not by way of limitation, and, together with the description, further serve to explain the principles of the invention and to enable a person skilled in the pertinent art to make and use the invention.

FIG. **1** is an illustration of an athlete using a portable fitness monitoring system according to an embodiment of the present invention.

FIG. **2** is an illustration of a strap attached to the wrist of an athlete according to an embodiment of the present invention.

FIG. **3**A is a front elevational view of a strap according to an embodiment of the present invention.

FIG. **3**B is a rear elevational view of a strap according to an embodiment of the present invention.

FIG. **4**A is a plan view of a display module according to an embodiment of the present invention.

FIG. **4**B is a bottom side view of a display module according to an embodiment of the present invention.

FIG. **5**A is a top perspective view of a portion of a display module according to an embodiment of the present invention.

FIG. **5**B is a side view of a portion of a display module according to an embodiment of the present invention.

FIG. **6**A is a plan view of a display module according to an embodiment of the present invention.

FIG. **6**B is a front sectional view of the display module of FIG. **6**A taken at the sectional plane A-A in FIG. **6**A according to an embodiment of the present invention.

FIG. **7** is an illustration of a display module and a strap according to an embodiment of the present invention.

FIG. **8** is a diagram of combined display modules and straps according to an embodiment of the present invention.

FIG. **9** is a block diagram of components of a display module according to an embodiment of the present invention.

FIG. **10** is an illustration of a display module interacting with a computer and/or a server according to an embodiment of the present invention.

FIG. **11** is table that illustrates heart rate zone ranges according to an embodiment of the present invention.

FIG. **12**A is an illustration of a combined display module and strap according to an embodiment of the present invention.

FIG. **12**B is an illustration of a combined display module and strap according to an embodiment of the present invention.

FIG. **13** is an illustration of a user interface according to an embodiment of the present invention.

FIG. **14** is a flow chart illustrating heart rate zone adjustments according to an embodiment of the present invention.

FIG. **15**A is an illustration of a shirt according to an embodiment of the present invention.

FIG. **15**B is an illustration of a shoe according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will now be described in detail with reference to embodiments thereof as illustrated in the accompanying drawings. References to "one embodiment", "an embodiment", "an example embodiment", etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

FIG. **1** is a diagram of an athlete **102** using a portable fitness monitoring system **100** according to an embodiment of the present invention. The fitness monitoring system **100** may be used to provide performance feedback to an athlete **102**. In one embodiment, the performance feedback may be provided by displaying to the athlete an indication of one or more performance zones based on one or more performance parameters associated with the athlete's **102** physical activity.

As depicted in FIG. **1**, in one embodiment, the monitoring system **100** includes an article for wearing **110**, a display module **140**, and a sensor **180**. The article for wearing **110** may be releasably secured to the body of the athlete **102**, and the display module **140** may be releasably secured to the article for wearing **110**. The display module **140** and the sensor **180** may communicate over a wireless communications network. In one embodiment, the display module **140** and the sensor **180** may communicate using a low-power wireless communications protocol and form part of a wireless personal area network (WPAN). For example, the components of the monitoring system **100** may communicate over a network using one or more of the following protocols: ANT, ANT+Sport by Dynastream Innovations, Bluetooth Low Energy Technology, Zigbee, Simplicity or BlueRobin. Other known communication protocols suitable for a fitness monitoring system may be used.

The portable fitness monitoring system **100** is shown being used by an athlete **102** while running. In addition to being used by runners, the monitoring system **100** can be used by individuals engaged in a variety of physical activities including, but not limited to, walking, biking, skating, swimming, skiing, performing aerobic exercises, weight lifting, or participating in various individual or team sports. Accordingly, terms such as, for example, "athlete," "runner," "exercising individual," and "user" may be referred to herein interchangeably.

The sensor **180** measures one or more performance parameters associated with the athlete's **102** physical activity, and communicates data relating to the performance parameters to the display module **140**. The term "performance parameters" may include physical parameters and/or physiological parameters associated with the athlete's **102** physical activity. Physical parameters measured may include, but are not limited to, for example, time, distance, speed, pace, pedal count, wheel rotation count, stride count, stride length, stride rate, altitude, strain, and/or impact force. Physiological parameters measured may include, but are not limited to, for example, heart rate, heart rate variability, blood oxygen level, blood flow, hydration level, respiration rate, calories burned, and/or body temperature. The sensor **180** typically acts as a WPAN transmitter.

The sensor **180** depicted in FIG. **1** is a heart rate sensor **182**. Heart rate sensor **182** may be used to determine the heart rate of the athlete **102**. In an embodiment, the heart rate sensor **182** may be integrally and fixedly incorporated into or releasably attached to clothing worn by athlete **102**. In another embodiment, the heart rate sensor **182** may be integrally and fixedly incorporated into or releasably attached to a chest strap **184** worn by the athlete **102**.

While the accompanying description is primarily directed towards embodiments wherein the sensor **180** is a heart rate sensor **182**, those skilled in the art will readily recognize that a variety of performance parameter sensors **180** may be used in place of, or in conjunction with, the heart rate sensor **182**, including, but not limited to, an accelerometer, a pedometer, a pulsimeter, a thermometer, an altimeter, a pressure sensor, a strain gage, a bicycle power meter, a bicycle crank or wheel position sensor, or other sensor for detecting a user performance parameter.

In one embodiment of the present invention, the display module **140** may act as a WPAN receiver. It may receive data from other components of the portable fitness monitoring system **100**, such as the heart rate sensor **182**, and it may provide performance feedback to the athlete **102**. In an embodiment, feedback is provided to the athlete **102** using a display. As discussed in further detail below, the feedback may be provided through one or more visual, audible, and/or sensory means. In one embodiment, the display module **140** also acts as a transmitter and transmits data and information to other components within and/or outside of the monitoring system **100**.

The article for wearing **110** may be releasably secured to the body of the athlete **102**, and the display module **140** may be releasably secured to the article for wearing **110**. In an alternative embodiment, the display **140** module may be permanently fixed to or integrally formed with the article for wearing **110**. With reference to FIGS. **1** and **2**, the article for wearing **110** is depicted as a strap **112** releasably secured to the wrist **104** of the athlete **102**. In alternative embodiments of the present invention, the article for wearing **110** may include, but is not limited to, for example, a band, a glove, a hat, a jacket, a shirt, a pair of pants, a sports bra, an article of footwear, a piece of eyewear, a ring, or any other article

capable of being worn by an athlete **102**. In some embodiments, article for wearing **110** may be an article of clothing with a sensor **180** incorporated therein. In some embodiments, the display module **140**, the article for wearing **110**, and the sensor **180** may all be integrally connected. In other embodiments, the display module **140**, the article for wearing **110**, and the sensor **180** may be physically separate, discrete components.

In one embodiment, the physically separate, discrete display module **140**, article for wearing **110**, and sensor **180**, may be releasably connected and in wired communication with one another. For example, an article for wearing **110** may be a jacket or other piece of outerwear including one or more wires fixed to, incorporated into, and/or passing through at least one layer of the jacket. The one or more wires may terminate with connector ports at portions of the jacket that are accessible to the athlete **102**. The athlete may then attach the display module **140** and sensor **180** to the connector ports thus enabling wired communication between the display module **140**, article for wearing **110**, and sensor **180**.

In other embodiments, the article for wearing **110** can be secured somewhere else on the athlete's **102** body such as, for example, on the athlete's forearm, finger, head, chest, hip, or foot. Portions of the article for wearing **110** that are closer to the part of the body of the user **102** than the article for wearing **110** is secured to may be referred to herein as the "inner" **132** portions of the article of wearing **110**, while portions that are further from the part of the body of the user **102** than the article for wearing **110** is secured to may be referred to herein as the "outer" **134** portions.

FIGS. **3**A and **3**B are illustrations of an article for wearing **110** in the form of a strap **112** according to one embodiment of the present invention. The strap **112** is adapted to be releasably secured to the wrist **104** of an exercising individual **102**. The strap **112** may be flexible to fit around the user's **102** wrist **104**, and may have a central portion between first and second end portions. In one embodiment, the strap **112** may be molded out of a flexible polymeric material, such as, for example, polyurethane. Other materials, including, but not limited to, rubber, plastic, TPU, cloth, leather, PU, silicon, metal, and/or other suitably flexible materials may be used. In one embodiment, the strap **112** may be injection molded. Flexible straps **112** may be formed from inflexible materials such as, for example, a plurality of small metal rings or pieces linked together to form a mesh-like strap. More traditional metallic straps such as those commonly employed in wrist watches that are comprised of a series of interconnected members may also be employed. Other suitable manufacturing techniques may be used.

The strap **112** may include fastening means **114** for releasably securing the strap **112** around the wrist **104**. In one embodiment, a fastener **114** may have one or more male and female components for securing the strap **112** around the wrist **104**. The components of the fastener **114** may be injection molded and integrally formed with the strap **112**, or they may be separate components. Multiple female components may be provided along the length of strap **112** so that the strap **112** is adaptable to varying wrist **104** sizes. One or more male components may be provided to engage with one or more of the female components. The strap **112** may additionally include ridges **116** to keep any overlapping first and second end portions of the strap **112** in a relatively parallel configuration. The inner surface **132** of the strap **112** may include dimples and/or protuberances **118** or other surface characteristics to limit relative motion between the inner surface **132** of the strap **112** and the athlete's **102** wrist **104**.

Other fastening means **114** may be used to releasably secure the strap **112** around the wrist **104**, including, but not limited to, hook and loop fasteners (e.g., VELCRO®), snaps, buttons, buckles, clasps, magnets, or other suitable means. Generally speaking, any known fastening means including, but not limited to, those commonly used to secure a wristwatch to a wearer's wrist may be used. In one embodiment, the strap **112** may not include fastening means **114**. In this embodiment, the strap may be made of a suitably elastic material such that the strap **112** may remain releasably secured around the wrist **104** without fastening means. In another embodiment, the strap **112** may be a continuous loop lacking first and second ends. The continuous loop strap **112** may be made of a suitably elastic material such that the strap **112** may stretch to pass over the athlete's **102** hand and thereafter contract to remain releasably secured around the athlete's **102** wrist **104**.

The strap **112** may be configured such that the display module **140** may be releasably secured to the strap **112**. As shown in FIG. **3**B, the strap **112** includes a cavity **122** defined therein. The display module **140** may be secured within the cavity **122**. The cavity **122** may have an opening **124**. The opening **124** may be large enough that the display module **140** may be inserted into the cavity **122** through the opening **124**. In one embodiment, the opening **124** may be located on an inner surface **132** of the strap **112**. In other embodiments, the opening **124** may be located on an outer surface **134** of the strap or a side surface of the strap. In an embodiment, multiple openings may be provided so that the display module **140** could be inserted into the strap **112** from a variety of different entry points.

The display module **140** may be releasably secured within the cavity **122** of the strap **112** by any means known in the art including, but not limited to, snaps, clips, magnets, or adhesives. In one embodiment, the display module **140** is frictionally secured within the cavity **122**. When the strap **112** is made of a sufficiently flexible material, such as certain injection molded polymeric materials, the cavity **122** of the strap may be capable of releasably securing the display module **140** without the assistance of snaps, clips, magnets, adhesives, or the like. The ability of the cavity **122** to releasably secure the display module **140** may optionally be enhanced by contouring the interior surfaces of the cavity **122** to the corresponding exterior surfaces of the display module **140**, by fabricating the strap **112** cavity **122** out of a resilient material capable of elastic deformation, and/or by providing a lip **126** around an edge of the opening **124**, as illustrated in FIG. **3**B.

In one embodiment, the display module **140** is adapted to provide a visual output that is visible through the strap **112**. The visual output may be visible through a portion of the strap **112** surrounding the cavity **122**. In one embodiment, as shown in FIGS. **3**A and **3**B, an outer surface **134** of the strap **112** may include a window **128**. The window **128** and other portions of the outer surface **134** may present a homogeneous surface. "Homogeneous," as used herein, means that the window **128** and outer surface **134** of the strap **112** have substantially consistent characteristics over the substantial entirety of their surfaces. For example, the outer surface **134** including the window **128** in the embodiment shown in FIGS. **2** and **3**A has visually consistent characteristics and texturally consistent characteristics over the substantial entirety of the outer surface **134**.

In an embodiment, at least a portion of the window **128** may be separable from the rest of the strap **112**. For example, the window **128** may be entirely removable from the strap **112**, or the window **128** may be fixedly attached to the strap **112** but may be capable of "opening" by rolling up, folding back, sliding back, or otherwise exposing the cavity **122** underlying the window **128**.

In one embodiment, as shown in FIG. **3**A, where the window **128** is not separable from the strap **112**, the window **128** of the outer surface **134** of the strap **112** may have a depression **120**. As described in further detail below, the depression **120** may indicate a portion of the window **128** that may be touched, depressed, or otherwise interacted with by the user **102** to actuate an input control **160**. In an embodiment, the depression **120** is relatively smooth and shallow so as not so disrupt the aesthetically uniform nature of the outer surface **134**.

In one embodiment, all or a substantial portion of the strap **112**, including the outer surface **134** and the window **128**, is made of a single, integrally formed piece of material. This single piece of material may be a flexible polymeric material, such as polyurethane or other suitable materials, as discussed above.

The display module **140** may include a display for providing a visual output. In one embodiment, the visual output is responsive to heart rate data received from the heart rate sensor **182**. The display may include multiple sub-displays capable of displaying different types of information or displaying the same information in different ways, as described in further detail below.

In embodiments of the present invention, the display module **140** may be adapted to provide non-visual output, including, but not limited to, audible output and other sensory output. For example, the display module **140** may include a speaker for providing audible output to the athlete **102**. The display module **140** may include means for vibrating the module **140**, such as, for example, a piezoelectric actuator, for providing sensory output to the athlete **102**.

In one embodiment of the present invention, as shown in FIGS. **4**A and **4**B, the display module **140** may be a pod including a housing having top **144** and bottom **146** surfaces, respectively. As used herein, "top surface" refers to a surface of the display module **140** that is furthest from the part of the body of the user **102** that the article for wearing **110** (or strap **112**) is secured to, while "bottom surface" refers to a surface of the display module **140** that is closest to the part of the body of the user **102** that the article for wearing **110** (or strap **112**) is secured to. In one embodiment, the display module **140** housing (including top **144** and bottom **146** surfaces) may be made of plastic, such as, for example, TPU, nylon, glass-filled nylon, or polycarbonate. Other materials suitable for the display module may be used.

As shown in FIGS. **5**A and **5**B, the display module **140** may include a circuit board **168** for supporting the necessary electrical components of the device, as will be appreciated by those of skill in the art. The circuit board **168** may include visual display means. In one embodiment, the visual display means includes a first display **148** and a second display **150**. The first display **148** may be capable of displaying alphanumerical information, while the second display **150** may be capable of displaying information based on the color and/or blink rate of one or more light emitting sources, such as light emitting diodes (LEDs). The circuit board **168**, including first display **148** and a second display **150**, may be contained within the display module **140** housing between the top **144** and bottom **146** surfaces.

In one embodiment, the visual display means, such as the first display **148** and the second display **150**, may be supported by another surface besides the circuit board.

The display module **140** may include one or more input controls **160**, such as, for example, buttons, dials, touch sensors, or switches, for manually interacting with the device. In an embodiment, the input controls may be voice-activated controls. The input controls **160** may be used, for example, to influence at least one characteristic of the visual output. In one embodiment, as shown in FIG. **4**B, an input control **160** may be a bottom button **161** located on a bottom surface **146** of the display module **140**. The bottom button **161** may be provided in a recess **170** formed in the bottom surface **146** such that the bottom button **161** is flush with the bottom surface **146** and is thus protected from being inadvertently manipulated when the bottom surface **146** makes contact with another surface, e.g., the user's **102** wrist **104**.

In one embodiment, as shown in FIGS. **5**A, **5**B, and **6**B, an input control **160** may be a top button **162** coupled to the circuit board **168**. The top button **162** may be aligned with an aperture **172** formed in the top surface **144** of the display module. As shown in FIGS. **4**A, **6**A, and **6**B, a flexible casing **154** may span the aperture **172** covering the top button **162**. Accordingly, the flexible casing **154** may be depressed by the user **102** to actuate the top button **162**. In one embodiment, the flexible casing **154** is made of a flexible polymeric material. In another embodiment, the aperture **172** and casing **154** are not present and the top surface **144** is a continuous surface that is flexible enough that it may be depressed to actuate the top button **162**.

As shown in FIGS. **5**A and **5**B, the circuit board **168** may include a first display **148**. The first display **148** may be an alphanumerical display capable of displaying both letters and numbers. In one embodiment, the first display **148** comprises a flexible LED substrate, such as those sold by Avago Technologies of San Jose, Calif. In one embodiment of the present invention, the first display **148** may include one or more seven-segment displays. In another embodiment of the present invention, the first display **148** may include one or more dot-matrix displays. The first display **148** may utilize LED, liquid crystal display (LCD), organic light emitting diode (OLED), or any other light-generating or light-controlling technologies known in the art.

The first display **148** may be positioned just below the top surface **144** of the display module **140** housing. As illustrated by FIG. **6**A, if the top surface **144** is sufficiently translucent or transparent, when the first display **148** is activated, visible light may be emitted and transmitted through the top surface **144**.

The first display **148** is adapted to display a numerical value based on performance parameter data received from the sensor **180**. In one embodiment, the first display **148** may display a numerical heart rate value based on heart rate data received from the heart rate sensor **182**. In other embodiments, the first display **148** may display a value associated with another user performance parameter, including, but not limited to, time, distance, speed, pace, pedal count, wheel rotation count, stride count, stride length, stride rate, altitude, strain, impact force, respiration rate, calories burned, and/or body temperature.

As shown in FIGS. **5**A, **5**B and **6**B, the circuit board **168** may include a second display **150**. The second display **150** may be capable of displaying information based on the color and/or blink rate of one or more light emitting sources, such as one or more single or multi-color LEDs. The second display may also have a casing **154**. In one embodiment, as shown in FIGS. **4**A, **6**A, and **6**B, the casing **154** above the

light emitting source may be the same casing **154** as the casing **154** that spans the aperture **172** covering the top button **162** (or any other input control **160**), such that the casing **154** may be depressed by the user to actuate the top button **162**, as described in further detail below. In embodiments where the top surface **144** is continuous and sufficiently flexible, the top surface **144** may be depressed instead, as described above.

The second display may include a one ore more single or multi-color LEDs contained beneath the casing **154**. When the semiconductor diode of an LED is forward biased (i.e. turned on), visible light may be emitted by the LED and transmitted through the casing **154**. In an embodiment, the casing **154** is transparent. In another embodiment, the casing **154** is translucent. The casing **154** may be of such translucent character that light from the one or more LEDs may be able to pass through it, but the physical components of the top input button **162** and/or the second display **150** itself may not viewable through the casing **154**. The color of the light emitted by the one or more LEDs is determined by the energy gap of the semiconductor. Methods of activating and deactivating LEDs and of producing different colors of light from single and/or multi-color LEDs are well known in the art and will not be described in further detail herein. In an embodiment, the one or more LEDs are bottom-emitting LEDs.

In one embodiment of the present invention, the casing **154** that spans the aperture **172** covering the top button **162** may be depressed by the user to actuate the top button **162**. The user **102** may, for example, activate the top button **162** by physically pushing the casing **154** downward in the direction of the bottom surface **146** of the display module **140**. In another embodiment, the casing **154** and an electrically conductive input control **160** may be capable of functioning as a capacitance, touch, and/or proximity sensor. In this embodiment, the user **102** could activate the input control **160** by simply touching the casing **154** with their finger. The functioning of capacitance switches is well known to those of skill in the art. FIG. **8** illustrates an athlete **102** activating an input control **160** (which may or may not be the top button **162**) through the casing **154** in one embodiment.

The second display **150** may be capable of displaying information based on the color and/or blink rate of one or more light emitting sources, such as LEDs, that are based on performance parameter data including data received from a sensor **180**. In one embodiment, the light emitting sources of the second display **150** may blink at a rate that is based on heart rate data received from the heart rate sensor **182**. In another embodiment, the light emitting sources of the second display **150** may emit a colored light, the color of which is responsive to the heart rate data received from the heart rate sensor **182**. The user **102** may activate the top button **162** by physically pushing the casing **154** of the second display **150** downward in the direction of the bottom surface **146** of the display module **140**. In this manner, the user **102** may have the unique experience of activating and/or manipulating one or both of the displays **148** and/or **150** by applying pressure to an area of the top surface **144** of the display module **140** underneath which the second display **150** and the top button **152** are located.

With reference to FIG. **7**, in one embodiment of the present invention, the display module **140** may be inserted into the cavity **122** of the strap **112** prior to use. As shown in FIG. **7**, in one exemplary embodiment, while the strap **112** is free from the wrist **104** of the athlete **102**, the athlete **102** first places the display module **140** adjacent to the opening **124** of the cavity **122**. The opening **124** of the cavity **122** is on the inner surface **132** of the strap **112**, and the display module **140** is configured such that the top surface **144** of the display module is facing the opening **124**. Next, the athlete manipulates the display module **140** and the strap **112** so that the display module **140** is urged into the interior of the cavity **122**, where it is releasably held in position. The athlete may similarly manipulate the combined display module-strap structure (**140** and **112**) if the athlete desires to remove the display module **140** from the strap **112**. Manipulation may involve pulling, pushing, or otherwise applying force with one's hands to the display module **140** and the strap **112** such that the two become releasably combined or physically separated, as desired by the athlete **102**.

In one embodiment, the exterior of the display module **140** and the cavity **122** of the strap **112** are complementarily contoured such that these elements can join together with little or no space between their respective surfaces. In another embodiment, the cavity **122**, opening **124**, lip **126**, and window **128** regions of the strap **112** are made from an elastically deformable material so as to aid in receiving and releasing the display module **140**. In a further embodiment, the display module **140** itself includes elements that are elastically deformable so as to aid in entering and leaving the cavity **122**.

When the display module **140** and the strap **112** are combined, the window **128** of the strap **112** may cover the entire top surface **144** of the display module **140**, including the aperture **172** and the casing **154**. Alternatively, the window **128** may cover only one or both of the regions of the top surface **144** immediately adjacent to the underlying first and second displays **148** and **150**.

As further illustrated in FIG. **8**, the depression **120** may be immediately on top of and aligned with the casing **154** spanning the aperture **172** of the top surface **144** of the display module **144**. Thus, the depression **120** may also aligned with the top button **162**. Accordingly, the user **102** may activate and/or manipulate one or both of the displays **148** and **150** by applying pressure to the depression **120** which transmits the force to the casing **154** of the display module **140** underneath which the second display **150** and the top button **152** may be located. Activation and/or manipulation may occur when the pressure is transmitted to and received by the top button **152**.

As shown in the embodiment of FIG. **8**, once the display module **140** has been inserted into the strap **112**, the display module is capable of providing a visual output that is visible through the window **128** of the strap **112**. While light provided by the displays **148** and **150** may always be able to shine through the window when the displays **148** and **150** are activated, depending on the properties of the material used to form the window **128**, all, some, or none of the top surface **144** of the display module **140**, including the aperture **172** and the casing **154**, may be visible to the athlete through the window **128**.

In one embodiment, the top surface **144** of the display module **140**, including the aperture **172** and the casing **154**, may not be viewable through the window **128** of the strap **112**. In this embodiment, the window **128** may include a translucent surface. When the displays **148** and **150** are in an inactive state, the top surface **144** of the display module **140**, including the aperture **172** and the casing **154**, may not be viewable through the window **128** because the window **128** may cover and obscure them with the translucent surface that may allow relatively little light to pass through. When the displays **148** and **150** are in an active state, while the light emitted from the active displays **148** and **150** may be

viewable through the translucent window **128**, the top surface **144** of the display module **140**, including the aperture **172** and the casing **154**, may not be.

In another embodiment, the top surface **144** of the display module **140**, including the aperture **172** and the casing **154**, may always be viewable through the window **128** of the strap. Regardless of whether the displays **148** and **150** are in an active or an inactive state, the top surface **144** of the display module **140**, including the aperture **172** and the casing **154**, may be viewable through the window **128** because, although the window may cover them, the window may be made of either a transparent material or a translucent material that may allow a relatively high amount of light to pass through, including ambient light from the external environment.

In other embodiments, the window **128** may have different regions with different light transmitting properties. For example, when paired with a display module **140** having first and second displays **148** and **150**, window **128** could have an obscuring translucent region covering only one or both of the regions of the top surface **144** immediately adjacent to the underlying first and second displays **148** and **150**.

In an embodiment, as described above, at least a portion of the window **128** may be separable from the rest of the strap **112**. For example, the window **128** may be entirely removable from the strap **112**, or the window **128** may be fixedly attached to the strap **112** but may be capable of "opening" by rolling up, folding back, sliding back, or otherwise exposing the cavity **122** underlying the window **128**. Any openings made by the window **128** may be aligned with one or both of the regions of the top surface **144** immediately adjacent to the underlying first and second displays **148** and **150**. In an embodiment, no window **128** is present and at least a top surface **144** of the display module **140** is exposed.

All, substantially all, or part of the strap **112**, including the window **128**, may be made of a single flexible material. In one embodiment, while the strap **112** may appear to be generally opaque along most of its length, the window **128** of the strap **112** may be a thinned portion that is sufficiently thin to allow some of the light from the displays **148** and **150** to be viewable when one or more of them are in an active state.

In one embodiment, because the strap **112** and the display module **140** are discrete components, a user may interchange multiple straps **112** without having to replace the display module **140**. The user may interchange a strap **112** with a strap **112** having a different size, shape, color, or design, for example, without changing the display module **140**. For example, the user may change the strap **112** to color coordinate with a uniform or outfit that the user is wearing. The strap **112** may also be adapted to display the colors or logo of the user's **102** favorite team. In this manner, the strap **112** may be marketed as a fashion article.

In a further embodiment, an article for wearing **110** may be comprised of a central unit including the cavity **122** for receiving the display module **140** and several peripheral units releasably attached to the central unit. For example, a strap **112** may include a central unit including the cavity **122** for receiving the display module **140**, and first and second arms releasably attached to the central unit. The first and second arms may have fastening means **114** at their ends, as described in further detail above, for connecting to each other, thus forming a complete strap when connected to the central unit. In this embodiment, the user **102** may interchange multiple first arms, second arms, and central units, without having to replace the display module **140**. Thus, as described above, the user **102** may interchange multiple pieces having different sizes, shapes, colors, or designs, for example, without changing the display module **140**, thus allowing the pieces to be combined into customizable fashion articles.

In one embodiment, the visual output of the display module **140** transmitted through the strap **112** is responsive to heart rate data received from the heart rate sensor **182**. In one embodiment, the first display **148** may display a numerical heart rate value based on heart rate data received from the heart rate sensor **182**, and the second display **150** may be capable of displaying heart rate data based on the color and/or blink rate of the one or more LEDs.

The heart rate sensor **182** may be any of a number of known heart rate sensing devices, such as, for example, those sold by Garmin, Suunto, or Oregon Scientific. The heart rate sensor **182** detects heart rate data from the athlete **102**. In an embodiment, the heart rate sensor **182** may be integrally incorporated into or releasably attached to a chest strap **184** worn by the athlete **102**. The heart rate sensor **182** may wirelessly transmit heart rate data to the display module **140**, where it is received by a heart rate receiver **166**.

In one embodiment, the heart rate sensor **182** wirelessly transmits one radio pulse for each detected heart event (e.g. a heart beat). In another embodiment, the heart rate sensor **182** wirelessly transmits a uniquely coded data signal that prevents the user's **102** display module **140** from receiving data from other nearby heart rate sensors **182** not associated with the user **102**. Transmission may occur in real-time, at predetermined regular intervals, on demand, or after the physical activity is complete.

In one embodiment of the present invention, the display module **140** may not record and log performance data in memory for later use. In other words, the heart rate or other performance parameter data may be used for real-time feedback, but are not recorded after they are used for this purpose. Also, while the display module **140** may include integrally formed visual displays **148** and **150**, in one embodiment, it may not provide a transmitter for transmitting data to other portable display devices, and may not provide audio output of any kind. Furthermore, the display module **140** may not communicate data with remote external elements such as a computer **200** or a server **202**. This embodiment may advantageously provide reduced size, weight, complexity, and cost as compared to other embodiments.

In another embodiment of the present invention, the display module **140** may record and log performance data in memory for later use. The display module **140** may receive performance parameter data and record performance parameter data, and may transmit performance parameter data to a personal computer **200** and/or a server **202**, as described in further detail below, for permanently storing and/or analyzing the performance data.

In a further embodiment, the display module **140** may provide a transmitter for transmitting data to other portable display devices, and may provide audio output, either through integrally formed audio output devices or portable audio output devices. Audio output may include audio performance feedback and/or music, as disclosed in commonly owned U.S. patent application Ser. No. 12/467,944, filed May 18, 2009, now U.S. Pat. No. 8,033,959, the disclosure of which is incorporated herein in its entirety by reference thereto.

In another embodiment, the display module **140** may communicate data with remote external elements such as a computer **200** or a server **202**, as disclosed in commonly

owned U.S. patent application Ser. No. 12/468,025, filed May 18, 2009, now published as U.S. Patent App. Pub. No. 2010/0292600, the disclosure of which is incorporated herein in its entirety by reference thereto.

As shown in FIG. **9**, in one embodiment, the display module **140** may include a processor **156**, a memory **158**, one or more input controls **160**, a heart rate receiver **166**, one or more displays **148** and **150**, and a computer input/output **164**. The display module **140** may be capable of receiving and processing heart rate data from the heart rate sensor **182** and generating a visual output via one or more displays **148** and **150**. The display module **140** may also include a power source, such as a battery.

In embodiments where the display module is capable of interacting with other sensors, other sensor receivers may also be present. For example, in an embodiment, the display module **140** may include an accelerometer receiver capable of communicating with an accelerometer.

The processor **156** may be capable of implementing application programs stored in the memory **158**. The processor **156** may also be capable of implementing analog or digital data signal processing algorithms. The processor **156** may be coupled to the memory **158**, the input controls **160**, the heart rate receiver **166**, the displays **148** and **150**, and the computer input/output **164**. In one embodiment, the processor **156** is model number CY8C21634 made by Cypress Semiconductor of San Jose, Calif.

The memory **158** may be used, for example to store application program instructions and to save recorded performance parameter data. In an embodiment, the memory **158** may store application programs, for example, used to implement aspects of the functionality of the portable fitness monitoring system **100** described further herein. In an embodiment, the memory **158** may include both read only memory and random access memory.

The user input controls **160** may be used by the athlete **102** to interact with the display module **140**. In an embodiment, the user input controls **160** may include one or more input buttons, dials, touch sensors, switches, and/or keys. The function of each of these buttons, switches, and/or keys is typically determined based on an operating mode of the display module **140**. In one embodiment, the user input controls **160** include a touch pad or scroll pad and/or touch screen buttons. In another embodiment, the user input controls **160** may be voice-activated controls, such as the RSC-4128 speech recognition microcontroller sold by Sensory, Inc. of Sunnyvale, Calif.

In one embodiment, the heart rate receiver **166** may be a low-power receiver used to communicate with the heart rate sensor **182** of the portable fitness monitoring system **100**. In an embodiment, the heart rate receiver **166** may operate in an unlicensed frequency band such as 2.4 GHz. The heart rate receiver **166** may be coupled to an antenna. The heart receiver **166** may also be a transceiver capable of bidirectional communication with the heart rate sensor **182**.

The computer input/output **164** may be any input/output device or transceiver capable of wired or wireless communication with a personal computer **200** and/or a server **202**, as described in further detail below.

In one embodiment, as shown in FIG. **10**, the display module **140** may communicate with a personal computer **200** using wired or wireless communications. Wired communication between the display module **140** and the personal computer **200** may be achieved, for example, by placing the display module **140** in a docking unit **208** that is attached to the personal computer **200** using a communications wire plugged into a communications port of the personal computer **200**. In another embodiment, wired communication between the display module **140** and the personal computer **200** may be achieved, for example, by connecting a cable between the display module **140** and the computer **200**. The computer input/output **164** of the display module **140** and a communications port of the computer **200** may include USB ports. The cable connecting the display module **140** and the computer **200** may be a USB cable with suitable USB plugs including, but not limited to, USB-A or USB-B regular, mini, or micro plugs.

Wireless communication between the display module **140** and the personal computer **200** may be achieved, for example, by way of a wireless wide area network (WWAN—such as, for example, the Internet), a wireless local area network (WLAN), or a wireless personal area network (WPAN) (collectively, wireless area networks or WANs). As is well known to those skilled in the art, there are a number of known standard and proprietary protocols that are suitable for implementing WANs (e.g. TCP/IP, ANT, ANT+Sport, Zigbee, Bluetooth Low Energy Technology, IEEE 802.16, and Bluetooth). Accordingly, the present invention is not limited to using any particular protocol to communicate between the display module **140** and the various elements of the fitness monitoring system **100** of the present invention.

In one embodiment, the display module **140** may communicate with a WWAN communications system such as that employed by mobile telephones. For example, a WWAN communication system may include a plurality of geographically distributed communication towers and base station systems. Communication towers may include one or more antennae supporting long range two-way radio frequency communication wireless devices, such as the display module **140**. The radio frequency communication between antennae and the display module **140** may utilize radio frequency signals conforming to any known or future developed wireless protocol, for example, CDMA, GSM, EDGE, 3G, IEEE 802.x (e.g., IEEE 802.16 (WiMAX)), etc. The information transmitted over-the-air by the base station systems and the cellular communication towers to the display module **140** may be further transmitted to or received from one or more additional circuit-switched or packet-switched communication networks, including, for example, the Internet.

As shown in FIG. **10**, communication may also occur between the personal computer **200** and a server **602** via a network **204**. In an embodiment, the network **204** is the Internet. The Internet is a worldwide collection of servers, routers, switches and transmission lines that employ the Internet Protocol (TCP/IP) to communicate data. The network **204** may also be employed for communication between any two or more of the display module **140**, the personal computer **200**, the server **202**, and the docking unit **208**. In an embodiment of the present invention, data may be directly communicated between the display module **140** and the server **202** via the network **204**, thus bypassing the personal computer **200** and the docking unit **208**.

A variety of data may be communicated between any of the display module **140**, the personal computer **200**, the network **204**, the server **202**, and the docking unit **208**. Such data may include, for example, performance parameters data, device settings (including display module **140** and sensor **200** setting), software, and firmware.

Communication among the various elements of the present invention may occur after the physical activity has been completed or in real time during the physical activity. In addition, the interaction between, for example, the display

module **140** and the personal computer **200**, and the interaction between the personal computer **200** and the server **202** may occur at different times.

Some of the display device **140** software and display device **140** and sensor **200** settings may relate to a zone-based system. In the zone-based system of the present invention, zones may be defined, for example, as ranges of percentages of an athlete's **102** maximum heart rate. Each zone may be associated with a particular color. An athlete's **102** maximum heart rate or speed may initially be provided to the display module **140**, the personal computer **200**, or the server **202** in a number of ways, as described below.

In one embodiment, the zones may be established based on a maximum user heart rate. An athlete's maximum heart rate can be provided to the display module **140** in a number of ways. If the athlete's **102** maximum heart rate is known, the athlete **102** may input the known maximum heart rate into the display module by, for example, actuating an input control **160**. Alternatively, if the athlete's **102** maximum heart rate is not known, the athlete **102** may input their age into the display module by, for example, actuating an input control **160**. In one embodiment, the user may enter both age and maximum heart rate information into the device. For example, when the device is turned on, the user **102** may press and hold the bottom button **162** of the display module **140** for five seconds. This may cause the word "age" to be displayed by the first display **148**. The user **102** may then repeatedly press the top button **161** as numerical age values are incrementally displayed by the first display **148**. When the user **102** reaches their age, they may press the bottom button **162** again causing the word "max" to be displayed by the first display **148**. The user **102** may then repeatedly press the top button **161** as numerical maximum heart rate values, if known, are incrementally displayed by the first display **148**. When the user **102** reaches their known maximum heart rate value, they may press the bottom button **162** to end the sequence. If the user **102** does no know their maximum heart rate value, they may press the bottom button **162** to bypass maximum heart rate entry.

In this case, the maximum heart rate can then be estimated based on one of many known formulas. According to one such formula, the athlete's **102** maximum heart rate is estimated to be two hundred and twenty minus the athlete's **102** age or:

$$HR_{MAX}=220-AGE$$

According to this formula, a thirty five year old athlete **102** would have an estimated maximum heart rate of 185 beats per minute. According to other formulas, other factors such as, for example, a user's height, weight, or gender may also be input to the display module **140** to determine an estimated maximum heart rate.

In an embodiment of the present invention, the maximum heart rate, age, or other information could be input the display module **140** via a remote computer.

In yet another embodiment, the athlete's **102** maximum heart rate may be determined by having the athlete **102** complete an assessment exercise. The athlete **102** could be prompted to, for example, run as fast as possible for 2 minutes. The display device would then be capable of measuring or estimating the athletes maximum heart rate based on the actual heart rates detected during the assessment exercise. In an embodiment, the user **102** could press and hold down the bottom button **162** of the display module **140** until the characters "ar" displayed by the first display **148**, representing "assessment run." The user **102** may then press the top button **161** to initiate the assessment run. A numerical indication displayed on the first display **148** may count down from, for example, 120 seconds while the user is intensely exerting themselves during the assessment run. During the first assessment run, the display module **140** may store the highest heart rate achieved by the athlete **102** during the run into memory **158** as that athlete's maximum heart rate value. During subsequent assessment runs, the display module **140** may only update the maximum heart rate value stored in the memory **158** if the athlete's **102** maximum heart rate during the subsequent assessment run exceeds the value stored in the memory **158**.

FIG. **11** is an exemplary illustration of zone definitions based on maximum heart rate for one embodiment of the present invention. An energy zone, ranging from 65% to 75% of an athlete's **102** maximum heart rate, may be associated with the color blue. An endurance zone, ranging from 75% to 85% of an athlete's **102** maximum heart rate, may be associated with the color green. A strength zone, ranging from 85% to 90% of an athlete's **102** maximum heart rate, may be associated with the color yellow. Finally, a power zone, ranging from 90% to 95% of an athlete's **102** maximum heart rate, may be associated with the color red. These ranges and color combinations are exemplary only; numerous other ranges and/or colors could be used.

The zones may be assigned based on predetermined fitness goals. For example, the energy zone (blue) may be associated with a heart rate range that allows an athlete **102** to build their aerobic base. The endurance zone (green) may be associated with a heart rate range that allows an athlete **102** to build cardiovascular strength and burn calories. The strength zone (yellow) may be associated with a heart rate range that allows an athlete **102** to improve their aerobic threshold and endurance. The power zone (red) may be associated with a heart rate range that allows an athlete **102** to improve their anaerobic threshold and metabolism.

Operation of the portable fitness monitoring system **100** according to an embodiment of the present invention will now be described. While the accompanying description is primarily directed towards embodiments wherein the sensor **180** is a heart rate sensor **182**, those of skilled in the art will readily recognize that a variety of performance parameter sensors **180** may be used.

Before the athlete **102** begins a physical activity, the athlete **102** secures the heart rate sensor **182** to his chest. The athlete also releasably combines the display module **140** and the strap **112**, as described above with respect to FIG. **7**, and activates the display module **140** by using a user input control **160**. Optionally, the athlete **102** may also use an input control **160** to select their desired visual output. At this time, the display module **140** may identify and begin to communicate with the heart rate sensor **182** via a WPAN to initiate the transmission of heart rate data from the heart rate sensor **182** to display module **140**. As the athlete **102** engages in physical activity, the heart rate receiver **166** receives heart rate data from the heart rate sensor **182**.

In an embodiment, the athlete **102** may not need to utilize an input control **160** to activate the display module **140** if the display module is already in a low-power, standby, or "sleep" mode. The display module **140** may automatically activate in response to receiving performance parameter data from a sensor **800**. Accordingly, the display module **140** may provide a "soft" power-on, which may allow for quicker and/or more efficient start ups. The soft power-on may occur in response to the display module **140** periodically searching for data transmissions from the sensor **180**.

When heart rate data is continuously transmitted to the portable fitness monitor in real time, the processor **156** may

process this data in accordance with a program stored in the memory **158** embodying the zone-based system. For example if a heart rate based zone system is employed and a user's **102** maximum heart rate has been input into the memory **158**, performance feedback may be provided to the athlete in real time via the visual displays **148** and **150**. For example, if the athlete **102** is exercising with a heart rate that the processor **156** determines is 80% of the athlete's **102** maximum heart rate, the second display **150** may illuminate a light emitting sources with the color green, corresponding to the endurance zone. An illuminated second display **150** is illustrated in FIG. **12**A.

In one embodiment, the color emitted by the second display **150** that corresponds to a particular heart rate zone may change in character in response to changes in the measured heart rate occurring within the zone. For example, the green light emitted may change in character in response to a measured heart rate increasing from a level near the bottom of the green zone to a heart rate level near the top of the green zone. The change in character may be, for example, a change in brightness or intensity. In an embodiment, the green light may change from a relatively light or dim light to a relatively dark or intense green as a user's **102** measured heart rate climbs upward through the green zone.

Performance feedback may be provided to the athlete **102** in real time via the displays that is not tied to the zone-based system. For example, if the athlete **102** is exercising with a heart rate that the processor **156** determines is 80% of the athlete's **102** maximum heart rate, which may be the equivalent of, for example, one hundred and thirty four beats per minute, the first display **148** may display the number "134." The second display **150** may blink one or more light emitting sources at a rate that is proportional to the user's **102** heart rate (i.e. blink at a rate of 134 pulses per minute, or a rate proportional thereto). In one embodiment of the present invention, the blink rate of the second display **150** is ⅓ of the measured heart rate so that the differences in blink frequency are more easily visually discernable. FIG. **12**A shows the second display **150** in its illuminated state (i.e. during a blink) and FIG. **12**B shows the second display **150** in its darkened state (i.e. between blinks). In an embodiment, the first display **148** could blink at a rate that is proportional to the user's **102** heart rate.

FIG. **8** illustrates a few examples of possible alphanumerical displays generated by the first display **148**. Numerical heart rate values displayed by the first display **148** may include, for example, instantaneous, average, and maximum heart rates. Other numerical information, such as current time, elapsed time, or date may also be displayed. Suitable programs and/or data signal processing algorithms programmed into the memory **158** may also enable the display module **140** to estimate the total number of calories burned during the physical activity. Various calorie estimating algorithms are known to those of skill in the art, including those disclosed in commonly owned U.S. Patent Application Pub. No. 2009/0047645, titled "Sports electronic training system, and applications thereof," the disclosure of which is incorporated herein in its entirety by reference thereto.

Text in the form of complete words or abbreviations may also be displayed, including text representing terms such as, for example, "heart rate," "average," "maximum," "calories," or "age." First display **148** may be a single alphanumerical display or may consist of several sub-display areas. In an embodiment, the first display **148** displays information on more than one row.

The display device **140** thus may provide a simple and intuitive way for an athlete **102** to observe information about his heart rate in real-time. In some embodiments, because of the arrangement of the input controls **160** and displays **148** and **150**, the presence of these elements is not obvious when viewing the exterior of the device. Because the device of embodiments of the present invention can be configured in such a minimalist form, its reduced size, weight, complexity, and cost may provide advantages over known monitoring systems and devices.

As performance data, such as, for example, heart rate data, is transmitted to the display module **140**, they may be stored in the memory **158** or transmitted to the server **202**. When performance parameter data is continuously transmitted to the display module **140** in real time, they may also be transmitted to the server **202** in real time. The performance parameter data may be processed by the processor **156** prior to storage or transmission. In an embodiment, performance parameter data is pre-processed by the sensors **180** themselves.

After the athlete **102** finishes his physical activity, the athlete **102** may deactivate the display module **140** by using a user input control **160**. Alternatively, the display module **140** may automatically deactivate in response to no longer receiving performance parameter data from the heart rate sensor **182**. The display module **140** may initiate a low-power, standby, or "sleep" mode in which power to one or more components is reduced or turned off. In this manner, the display module **140** may provide a "soft" off, which may allow a quicker and/or more efficient start up when the display module **140** is subsequently re-activated. Upon initiation of the deactivation procedure, the display module **140** may further ensure that data files or other recordings are completely saved and not closed prematurely prior to deactivation. This may be desirable to avoid loss of recorded performance parameter data. Once the physical activity is complete, the athlete **102** may initiate wired or wireless transmission of any stored performance parameter data to the personal computer **200** and/or the server **202**. Alternatively, the display module **140** or the computer **200** and/or server **202** may initiate the transmission of data. In an embodiment, transmission of performance parameter or other data from the display module **140** to the computer **200** and/or the server **202** may still occur even if the device is in a soft off, low-power state.

Data communicated to and stored by the personal computer **200** or the server **202** may be accessible to the athlete **102** at a later time. In the case of storage on the server **202**, the athlete **102** could access post-activity performance data communicated to the server **202** from their display module **140** at a later time from their personal computer **200** over the network **202**. In another embodiment of the present invention, a third party (e.g. a trainer, coach, friend, or family member) stationed at a personal computer **200** may be able to access real-time or historical performance information regarding the athlete's **102** performance via the server **202** over the network **204**.

The personal computer **200** and/or the server **202** may include software configured to includes a number of different modules capable of providing various fitness monitoring services to athletes **102**. Each module may support one or more graphical user interfaces (GUIs) capable of being presented to users at personal computers **200**. FIG. **13** is an exemplary illustration of a GUI window presented by a history software module showing a heart rate graph and other information derived from performance parameter data recorded during a single physical activity and transmitted from the display module **140** to a personal computer **200** and/or a server **202**.

In embodiments of the present invention capable of interacting with a personal computer **200**, any device settings of the display module or information capable of being input or altered via the input controls **160** may alternatively or additionally be input or altered via the computer **200**.

In addition to storing application program instructions and saving recorded performance parameter data, the memory **158** of the display module **140** may also be used, for example, to store workout routines **210**, as described in further detail below. The processor **156** may also be able of executing the workout routines **210**.

The personal computer **200** and/or the server **202** may include software configured to include a plan module to select a default workout routine, create a custom workout, or even select or customize an entire training plan comprised of individual workouts. Workouts may be scheduled on a virtual calendar, or may be saved without being associated with a particular date. Workout and plan creation is discussed in more detail in co-pending U.S. patent application Ser. No. 12/468,025, filed May 18, 2009, now published as U.S. Patent App. Pub. No. 2010/0292600, filed on the same day herewith, which is incorporated by reference in its entirety.

The user **102** may be able to select or create a workout routine **210** including different time intervals of different intensities, according to the color coded zone-based system described above. A workout may include, for example, a 5 minute warm up in the blue zone, then a 10 minute jog in the green zone, followed by a 5 minute run in the yellow zone.

In one embodiment, after a workout routine **210** is created, it may be sent through wired or wireless transmission from the computer **200** or server **202** to the display module **140** via the computer input/output **164**. One or more workout routines **210** may be received by the display module **140** and stored in the memory **158**. The processor **156** may be capable of executing the workout routines **210**.

In one embodiment, after the heart rate zones have been initially defined, the portable fitness monitoring system **100** may be adapted to selectively adjust the limits of the heart rate zones in response to the athlete's **102** performance and/or feedback received from the athlete, if such adjustments are warranted. In this manner, as illustrated in FIG. **14**, the portable fitness monitoring system **100** may provide a training feedback loop. As described above, the zones may be defined based on user input (e.g. maximum heart rate, age, and/or another input parameter). User heart rate data is detected during a physical activity via the heart rate sensor **182**, as described above. The heart rate data is transmitted to the computer **200** and/or the server **202** for processing. A determination is made as to whether the zones need to be adjusted. If adjustments are warranted, this data is communicated back to the display module **140**.

The determination as to whether or not the zones need to be adjusted may be based on performance data (e.g., heart rate data) and/or feedback received from the athlete. With respect to performance data, factors may include, for example, the athlete's **102** consistency during a particular physical activity, their rate of recovery after the activity, or their performance during specific interval training sessions, as specified by a workout routine **210**. For example, the athlete may use the fitness monitoring system **100** during workout routine **210** in which the intervals are based on maintaining a heart rate within a particular heart rate zone during the interval. If the athlete performs outside the specified heart rate zone for all or a portion of the interval, the heart rate zone may be adjusted. For example, if the athlete is consistently above the specified zone, the zone range may be increased. If the athlete is consistently below the specified zone, the zone range may be decreased.

Determinations may further be influenced by feedback provided by the athlete. For example, the athlete may provide responses to questions posed by the portable fitness monitoring system. For example, upon uploading recently recorded workout data, or upon logging in to the computer **200** and/or sever **202**, a GUI pop-up window may appear asking the user **102**, for example, if they thought the workout was too difficult or too easy. If the user responds that a workout was too difficult, the zone range may be incrementally decreased. If the user responds that a workout was too easy, the zone range may be incrementally increased.

In other embodiments, display module **140** may be capable of interacting with a portable fitness monitoring device **300**. The portable fitness monitoring device **300** may be a device such as, for example, a mobile phone, a personal digital assistant, or a music file player (e.g. and MP3 player), a GPS-enabled device, exercise equipment, a dongle (e.g. a small hardware device that protects software), or a dedicated portable fitness training device, such as the device disclosed in an embodiment of commonly owned U.S. patent application Ser. No. 12/467,944, filed May 18, 2009, now U.S. Pat. No. 8,033,959, the disclosure of which is incorporated herein in its entirety by reference thereto.

In other embodiments, the display module **140** may be capable of storing and executing workout routines, such as those disclosed in an embodiment of commonly owned U.S. patent application Ser. No. 12/467,944, filed May 18, 2009, now U.S. Pat. No. 8,033,959, the disclosure of which is incorporated herein in its entirety by reference thereto.

As indicated above, in addition to being a strap **112**, the article for wearing **110** may be, for example, a band, a glove, a hat, a jacket, a shirt, a pair of pants, a sports bra, an article of footwear, a piece of eyewear, a ring, or any other article capable of being worn by an athlete **102**. FIG. **15**A shows a display module **140** releasably attached to a long sleeved performance t-shirt **136**, while FIG. **15**B shows a display module **140** releasably attached to an athletic shoe **138**. In the embodiments of FIGS. **15**A and **15**B, the display module **140** is releasably secured in a cavity **122** in the article for wearing **110** (i.e. shirt **136** and shoe **138**, respectively), and the article for wearing **110** is provided with a window **128**. In an embodiment, the cavity **122** could be a pocket or pouch.

In another embodiment of the present invention, instead of being releasably secured to an article for wearing **110**, the display module **140** could be secured to a piece of exercise equipment, including, but not limited to, a bicycle.

In a further embodiment, the display **140** module may be permanently fixed to or integrally formed with the article for wearing **110**, as opposed to being releasably secured to it.

Some of the display modules **140** and various sensors **180** of the monitoring system **100** have been described above as being able to communicate over a network using one or more wireless protocols including, but not limited to, ANT+. In an embodiment, the display module **140** may further be able to communicate over a network using a wireless protocol with other devices including, but not limited to, foot pods, pedometers, inclinometers, treadmills, bicycles, power meters, cadence sensors, speed sensors, distance sensors, scales, body mass index scales, respiration sensors, global positioning service (GPS) devices, and altimeters.

As indicated above, in some embodiments, the display module **140** may be capable of storing and executing workout routines, such as those disclosed in an embodiment of commonly owned U.S. patent application Ser. No. 12/467,

944, filed May 18, 2009, now U.S. Pat. No. 8,033,959, the disclosure of which is incorporated herein in its entirety by reference thereto.

The athlete **102** may engage in physical activity while being guided in accordance with the workout routine, as the heart rate receiver **166** receives the performance parameter data. The workout routine may include different time intervals of different intensities, according to the color-coded zone-based system described above. Accordingly, the second display **150** could provide the athlete **102** with an indication about which zone they are in, while another color display could provide the athlete **102** with an indication about which zone they should be in, based on the workout routine.

In an embodiment, the display module **140** may include a speaker for providing audible output to the athlete **102** related to the workout routine. The display module **140** may include means for vibrating the module **140**, such as, for example, a piezoelectric actuator, for providing sensory output to the athlete **102**. This sensory output could indicate to the athlete **102** that they should look at the display module **140** to receive color-coded or other information about their performance and/or workout routine.

Embodiments of the present invention may employ an inductive charger for charging a battery that provides power to the device. As is known by those of skill in the art, inductive charging charges electrical batteries using electromagnetic induction. Induction chargers typically use an induction coil to create an alternating electromagnetic field from within a charging base station, and a second induction coil in the portable device takes power from the electromagnetic field and converts it back into electrical current to charge the battery. The two induction coils in proximity combine to form an electrical transformer.

A charging station may send energy through inductive coupling to an electrical device, which stores the energy in a battery. Because there is a small gap between the two coils, inductive charging is a kind of short-distance wireless energy transfer. This differs from standard conductive charging, which requires direct wired contact between the battery and the charger. Conductive charging is normally achieved by connecting a device to a power source with plug-in wires. In embodiments where the display module **140** can wirelessly communicate data with a computer **200** and/or server **202**, the display module **140** may also be adapted to wirelessly recharge via inductive charging. In an embodiment, an inductive charging post, receptacle, station, or any other sort of structure may be provided so that inductive charging and wireless transfer and/or reception can occur simultaneously at the same location. This advantageously may allow the display module **140** to be fabricated without any power outlets or removable battery closure lids.

In an embodiment of the present invention, fiber optic channels in the article for wearing **110**, such as the strap **112**, could allow the entire article for wearing **110**, or a substantial portion thereof, to glow from light output by the second display **150**.

While many of the exemplary embodiments discussed above make reference to a color-coded heart rate zone-based system, color-coded zone systems based on zones of other parameters including, but not limited to, speed, pace, stride rate, calories, respiration rate, blood oxygen level, blood flow, hydration status, or body temperature may also be employed. The present invention is therefore not to be limited to only heart rate based zone systems.

Furthermore, while many of the exemplary embodiments discussed above make reference to a color-coded heart rate zone-based system where the zones may be defined as ranges of percentages of an athlete's **102** maximum heart rate, heart rate zones may be defined based on other parameters as well.

In one embodiment, heart rate zones may be defined as ranges of percentages of an athlete's **102** maximum heart rate. In another embodiment, heart rate zones may be defined as ranges derived from parameters such as an athlete's **102** ventilation threshold heart rate. In a further embodiment, heart rate zones may be defined as ranges derived from both the athlete's **102** peak heart rate and the athlete's **102** ventilation threshold heart rate.

An athlete's **102** peak heart rate may or may not be the same as the athlete's **102** maximum heart rate. As used herein, "peak heart rate" refers to the highest heart rate that a particular athlete **102** can achieve during a training session. The athlete's physiologically possible maximum heart rate may be higher that the peak heart rate. For some athletes **102**, typically those in top physical condition, their peak heart rate may be very close to their max heart rate. For other athletes **102**, typically those who are less well conditioned, their peak heart rate may be far less than their true physiologically possible max heart rate. Accordingly, in an embodiment, an athlete **102** may enter their peak heart rate into their display module **140** or save this information on the server **202**. The athlete **102** may also be able to capture peak heart rate information during an assessment run, as described in further detail above.

As an exercise progressively increases in intensity, the air into and out of your respiratory tract (called ventilation) increases linearly or similarly. As the intensity of exercise continues to increase, there becomes a point at which ventilation starts to increase in a non-linear fashion. This point where ventilation deviates from the progressive linear increase is called the "ventilation threshold." The ventilation threshold is closely related to the lactate threshold, or the point during intense exercise at which there is an abrupt increase in blood lactate levels. Research suggests that the ventilation and lactate thresholds may be some of the best and most consistent predictors of performance in endurance events. The athlete's **102** heart rate at the ventilation threshold point may be referred to as their ventilation threshold heart rate. Accordingly, in an embodiment, an athlete **102** may enter their ventilation threshold heart rate into their display module **140** or save this information on the server **202**. The athlete **102** may also be able to capture ventilation threshold heart rate information during an assessment run, as described in further detail above, by using equipment necessary for determining ventilation and/or lactate threshold.

In an embodiment, the heart rate zones may be defined as ranges derived from both the athlete's **102** peak heart rate and the athlete's **102** ventilation threshold heart rate. For example, Table 1 illustrates an exemplary embodiment in which color-coded heart rate zones may be defined for an athlete **102** with a peak heart rate (PHR) of 200 beats per minute and a ventilation threshold heart rate (VTHR) of 170 beats per minute:

TABLE 1

ZONE BOUNDARY	CALCULATION	HR VALUE	% MAX HR
Upper Red Zone Limit (URZ)	=PHR	200	93.5%
Lower Red Zone Limit (LRZ)	=%110 of VTHR	187	87.4%

TABLE 1-continued

ZONE BOUNDARY	CALCULATION	HR VALUE	% MAX HR
Upper Yellow Zone Limit (UYZ)	=LRZ − 1	186	87.0%
Lower Yellow Zone Limit (LYZ)	=VTHR	170	79.5%
Upper Green Zone Limit (UGZ)	=LYZ − 1	169	79.0%
Lower Green Zone Limit (LGZ)	=UBZ + 1	154	72.0%
Upper Blue Zone Limit (UBZ)	=90% of VTHR	153	71.5%
Lower Blue Zone Limit (LBZ)	=80% of VTHR	135	63.1%

As illustrated by Table 1, each color coded zone may be defined as having upper and lower limits. Each zone limit may be calculated based on PHR, VTHR, and/or one of the other zone limits. A heart rate value associated with each zone limit may be correlated to a percentage of max heart rate if max heart rate is known or can be estimated. In an embodiment, PHR is assumed to be 93.5% of an athlete's **100** max heart rate value. Accordingly, physical activities may be carried out and content may be presented via GUIs according to the color-coded heart rate zone based system of the present invention.

As described above, color-coded pace or speed based systems may also be employed. In an embodiment, upper and lower pace or speed zone limits may be derived in part from PHR and VTHR values. For example, an athlete may conduct one or more physical activities using a heart rate monitor, a ventilation threshold (or lactate threshold) monitor, and/or pace or speed monitors. Measurements may be conducted by portable monitors, stationary monitors, or in a laboratory after the physical activities are conducted. A relationship between the pace or speed of the athlete and max heart rate, PHR, and/or VTHR may be established. Accordingly, color-coded pace or speed zone limits may be determined based on this information.

In another embodiment of the present invention, zones may be determined based on a measurement of power. Power measurements may be derived from pace calculations if other parameters such as, for example, the athlete's **102** body weight and the incline of the surface traversed (e.g. incline of a sidewalk, bike path, or treadmill surface).

The present invention has been described above by way of exemplary embodiments. Accordingly, the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalences.

What is claimed is:

1. A method of providing performance feedback to an individual using a portable fitness monitoring device, the method comprising:

sensing performance parameter information during the physical activity;

generating a first output that includes an indication of a target performance parameter intensity level that the individual should be performing at; and

generating a second output that includes an indication of a measured performance parameter intensity level that the individual is currently performing at,

wherein the second output further includes an indication of a color associated with the measured intensity level that the individual is currently performing at, and

wherein the second output changes a color intensity in response to a change in the measured performance parameter intensity level that the individual is currently performing at.

2. The method of claim **1**, wherein the first output further includes an indication of a color previously associated with the target performance parameter intensity level that the individual should be performing at.

3. The method of claim **1**, wherein the second output blinks in a first color at a first brightness level at a first performance parameter intensity zone and the second output blinks in the same color as the first color at a higher brightness level at a second performance parameter intensity zone.

4. The method of claim **1**, wherein the second output blinks in a color indicating a measured performance parameter intensity zone that the individual is currently performing at.

5. The method of claim **1**, wherein the second output is displayed in a first color at a first color intensity level at a first performance parameter intensity zone and the second output is displayed in the same color as the first color at a higher color intensity level at a second performance parameter intensity zone.

6. The method of claim **1**, wherein the sensing further comprises sensing speed or pace via the portable fitness monitoring device.

7. The method of claim **1**, wherein the performance parameter comprises one of a heart rate, speed, pace, stride rate, heart rate variability, blood oxygen level, blood flow, hydration level, respiration rate, and calories burned.

8. The method of claim **1**, further comprising receiving a touch input from the individual via a touch screen display during the physical activity, such that a characteristic of the second output is influenced.

9. The method of claim **1**, wherein the second output includes alphanumeric text corresponding to the measured performance parameter.

10. A method of providing performance feedback to an individual using a portable fitness monitoring device, the method comprising:

sensing performance parameter information during the physical activity;

generating a visual output that includes an indication of a measured performance parameter intensity level that the individual is currently performing at as compared to a target performance parameter intensity level that the individual should be performing at; and

changing one of blink frequency, color brightness, and color intensity of the visual output in response to a change in the measured performance parameter intensity level that the individual is currently performing at.

11. The method of claim **10**, wherein the visual output further includes a color previously associated with the performance parameter intensity level that the individual is currently performing at.

12. The method of claim **10**, wherein the performance parameter comprises one of a heart rate, speed, pace, stride rate, heart rate variability, blood oxygen level, blood flow, hydration level, respiration rate, and calories burned.

13. The method of claim **10**, further comprising:

providing a sensory output to the individual performing the physical activity.

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