US006658276B2

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

(10) **Patent No.: US 6,658,276 B2**
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(54) **PULSE OXIMETER USER INTERFACE**

(75) Inventors: **Massi E. Kianl**, Laguna Niguel, CA (US); **Ammar Al-Ali**, Tustin, CA (US); **Don Carothers**, Mission Viejo, CA (US); **Michael Lee**, Aliso Viejo, CA (US); **James Pishney**, Orange, CA (US); **Walter M. Weber**, Dana Point, CA (US)

(73) Assignee: **Masimo Corporation**, Irvine, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 11 days.

(21) Appl. No.: **10/076,860**

(22) Filed: **Feb. 12, 2002**

(65) **Prior Publication Data**

US 2002/0161291 A1 Oct. 31, 2002

Related U.S. Application Data

(63) Continuation-in-part of application No. 09/641,542, filed on Aug. 18, 2000, and a continuation-in-part of application No. 09/516,110, filed on Mar. 1, 2000, now Pat. No. 6,584,336, and a continuation-in-part of application No. 09/491,175, filed on Jan. 25, 2000, now abandoned.

(60) Provisional application No. 60/268,207, filed on Feb. 12, 2001, provisional application No. 60/161,565, filed on Oct. 26, 1999, and provisional application No. 60/117,097, filed on Jan. 25, 1999.

(51) **Int. Cl.**[7] **A61B 5/00**

(52) **U.S. Cl.** **600/322**; 600/323

(58) **Field of Search** 600/300, 301, 600/310, 322–324; 345/700, 864

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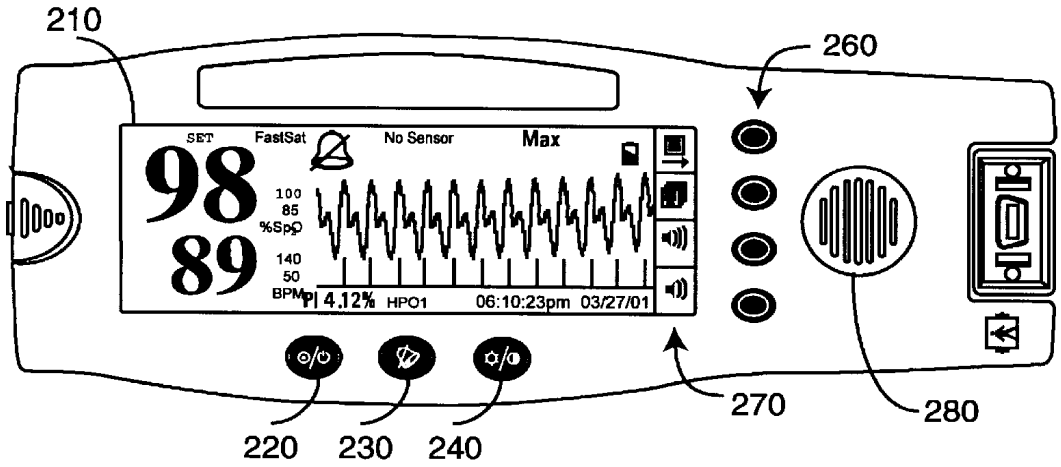
Copending U.S. application No. 10/153,263, filed on May 21, 2002 (Atty. No. 162CP1), and pending claims.

Primary Examiner—Eric F. Winakur
Assistant Examiner—David J. McCrosky
(74) *Attorney, Agent, or Firm*—Knobbe, Martens, Olson & Bear LLP

(57) **ABSTRACT**

A pulse oximetry user interface has a display and a plurality of views each configured to occupy the display. Each of the views are adapted to present data responsive to a physiological signal. A plurality of icons are configured to occupy a portion of the views and adapted to designate the content of the views. Further, a plurality of keys are proximate to the display and correspond to the icons so as to select the icons. One of the views is a pleth view that presents a pulse waveform. Another one of the views is a trend view that presents a trend graph. At least one of the icons can be selected so as to switch the display between the pleth view and the trend view.

7 Claims, 30 Drawing Sheets



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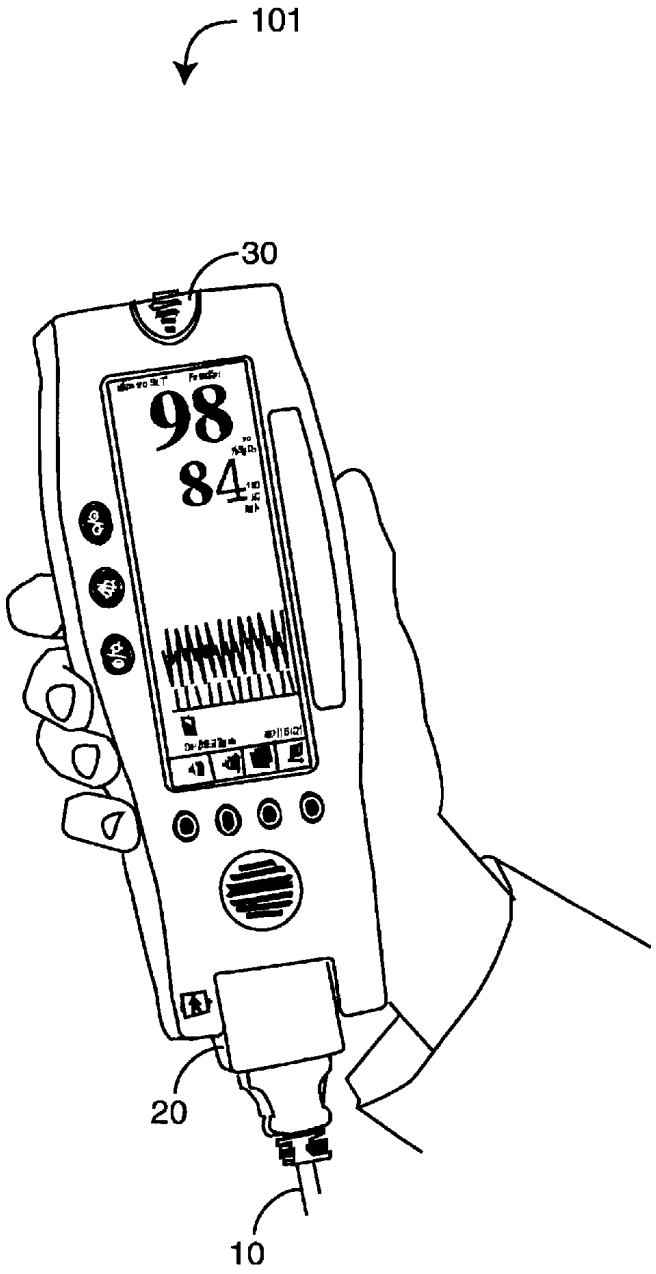


FIG. 1A

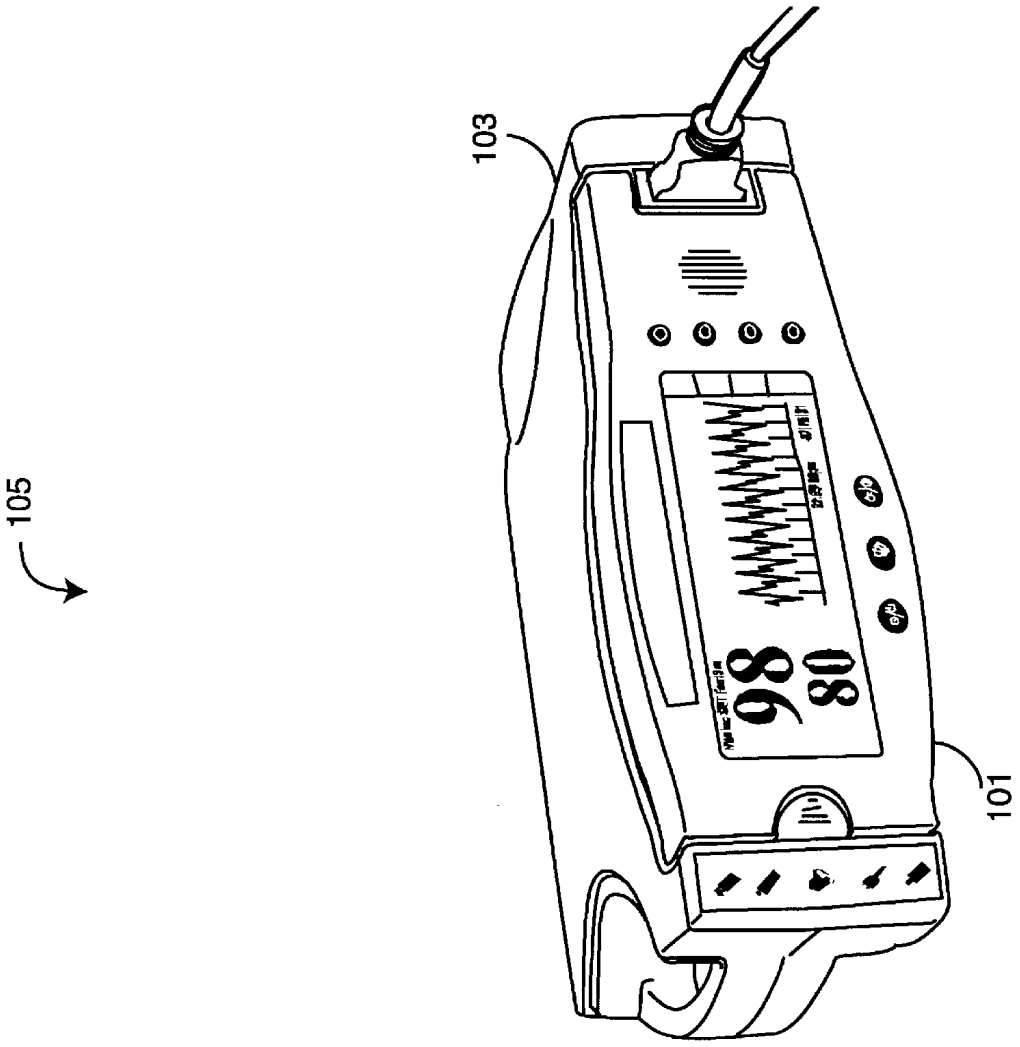


FIG. 1B

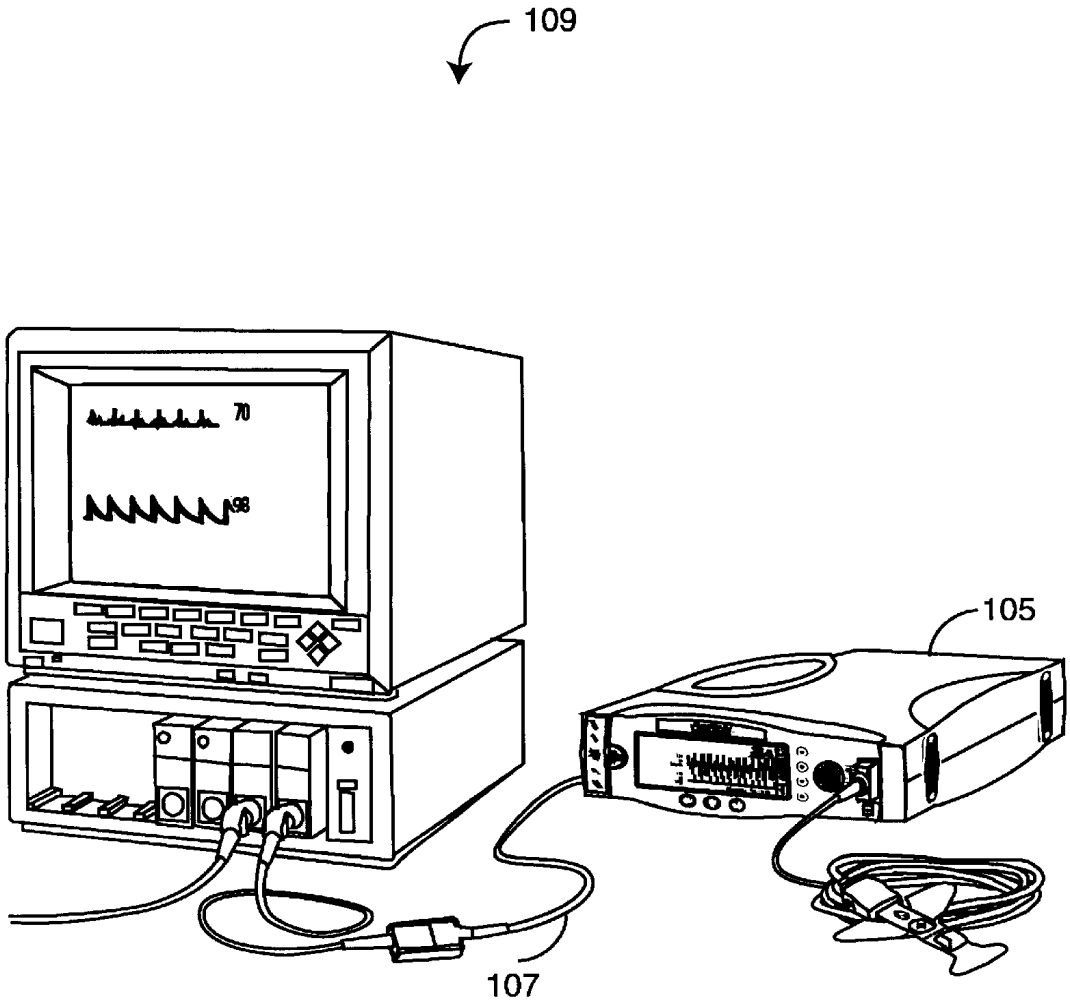


FIG. 1C

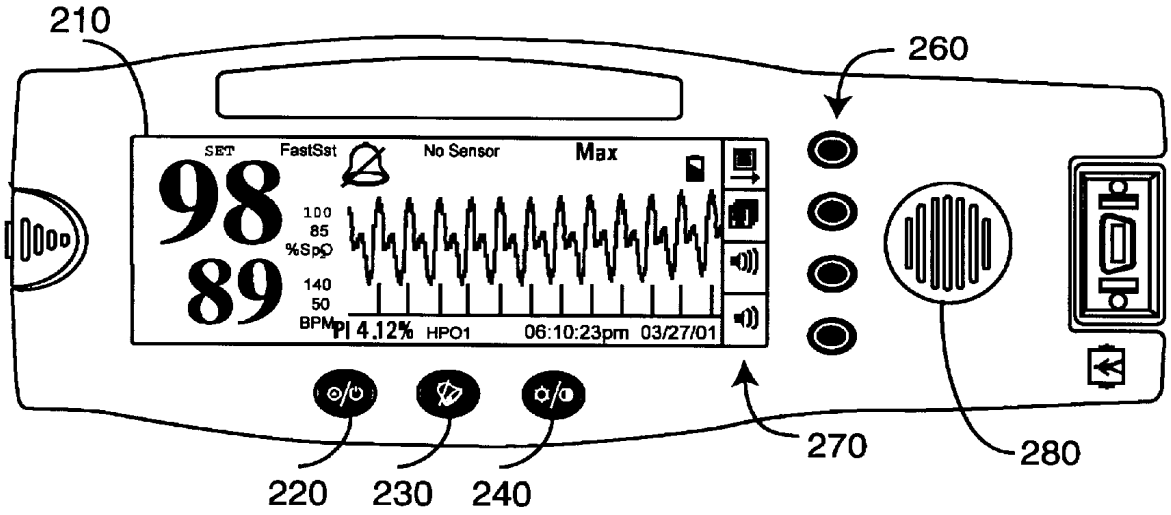

210
260
SET
FastSat
No Sensor
Max
98
89
100
85
%SpO
140
50
BPM
PI 4.12%
HPO1
06:10:23pm 03/27/01
220
230
240
270
280

FIG. 2A

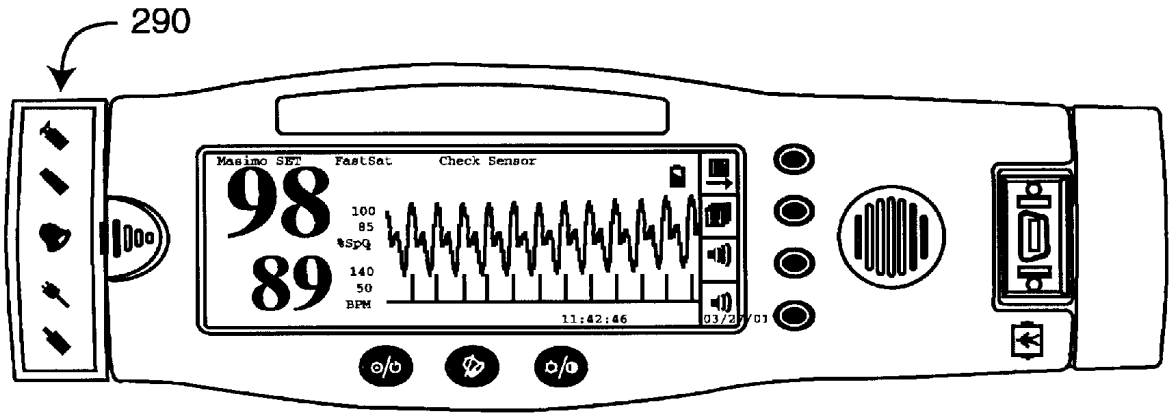

290
Masimo SET
FastSat
Check Sensor
98
89
100
85
%SpO
140
50
BPM
11:42:46

FIG. 2B

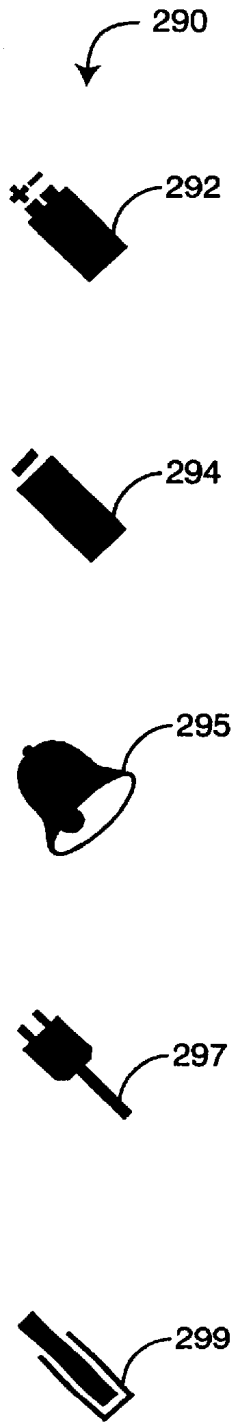


FIG. 2C

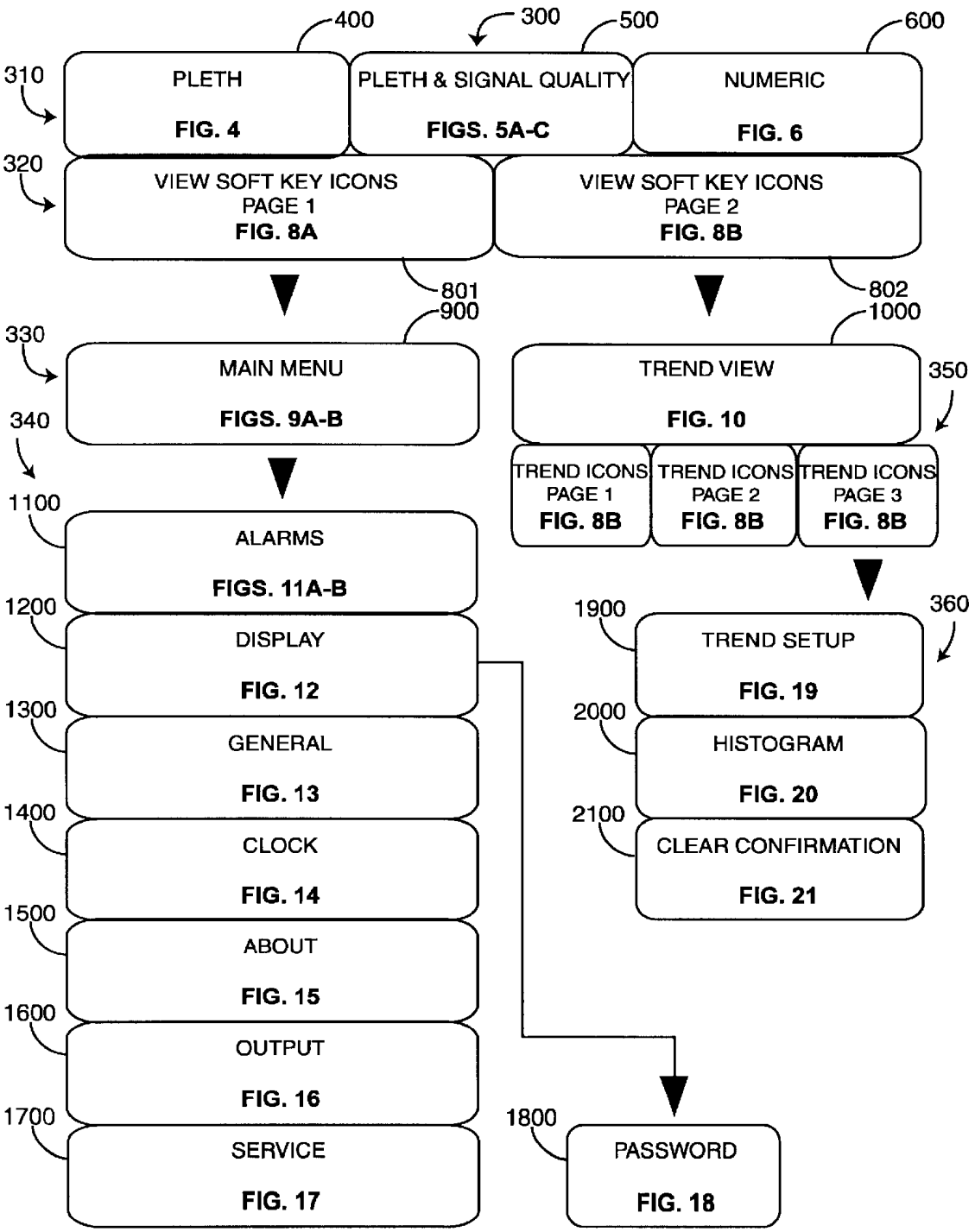

400
300
500
600
310
PLETH
FIG. 4
PLETH & SIGNAL QUALITY
FIGS. 5A-C
NUMERIC
FIG. 6
320
VIEW SOFT KEY ICONS PAGE 1
FIG. 8A
VIEW SOFT KEY ICONS PAGE 2
FIG. 8B
801
802
900
1000
330
MAIN MENU
FIGS. 9A-B
TREND VIEW
FIG. 10
350
340
TREND ICONS PAGE 1
FIG. 8B
TREND ICONS PAGE 2
FIG. 8B
TREND ICONS PAGE 3
FIG. 8B
1100
ALARMS
FIGS. 11A-B
1900
360
1200
DISPLAY
FIG. 12
TREND SETUP
FIG. 19
1300
2000
GENERAL
FIG. 13
HISTOGRAM
FIG. 20
1400
2100
CLOCK
FIG. 14
CLEAR CONFIRMATION
FIG. 21
1500
ABOUT
FIG. 15
1600
OUTPUT
FIG. 16
1700
1800
SERVICE
FIG. 17
PASSWORD
FIG. 18

FIG. 3

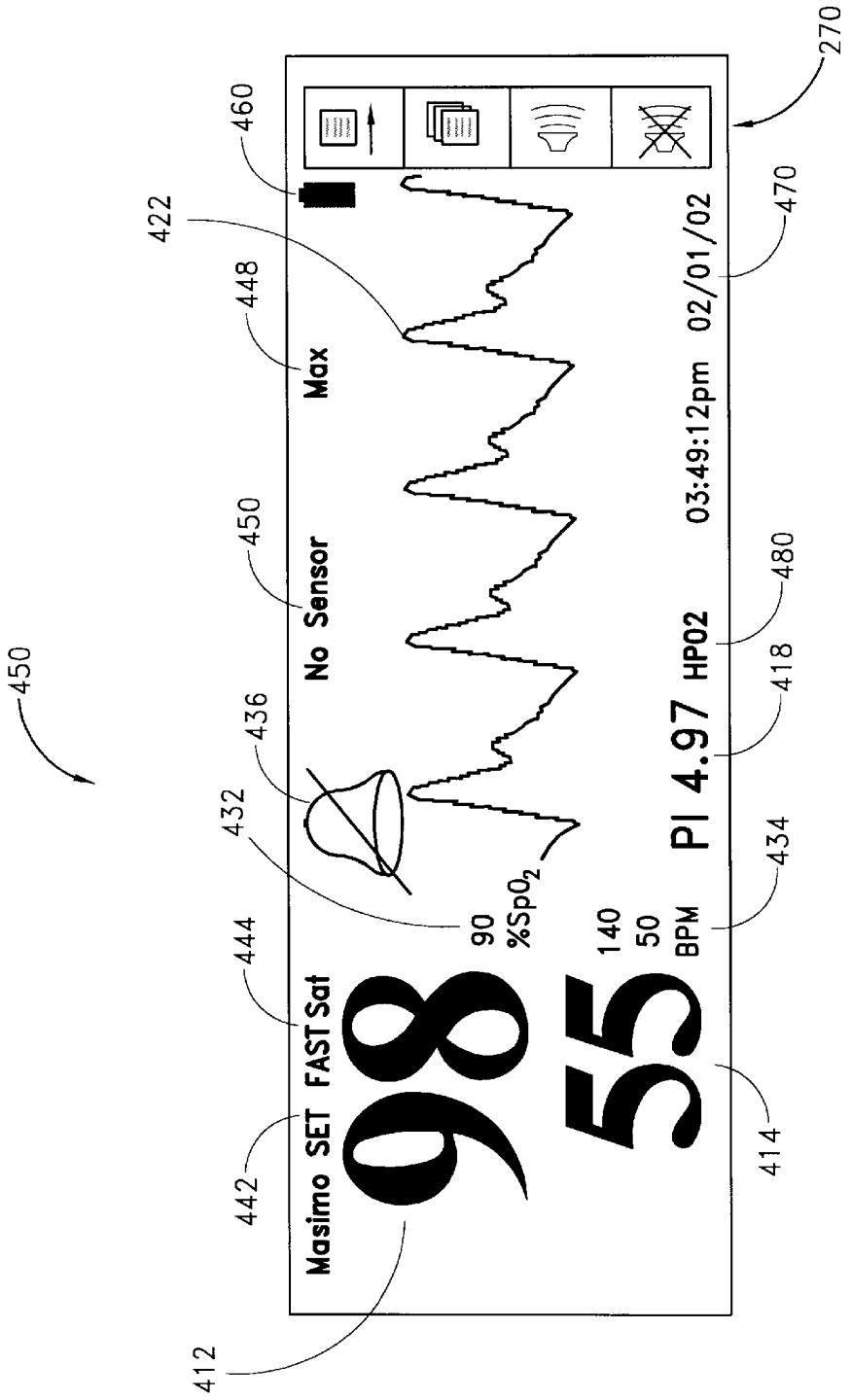

450
270
460
422
448
Max
450
No Sensor
436
432
444
442
Masimo SET FAST Sat
98
90
%SpO2
140
50
BPM
55
PI 4.97
HP02
03:49:12pm
02/01/02
470
480
418
434
414
412

FIG. 4

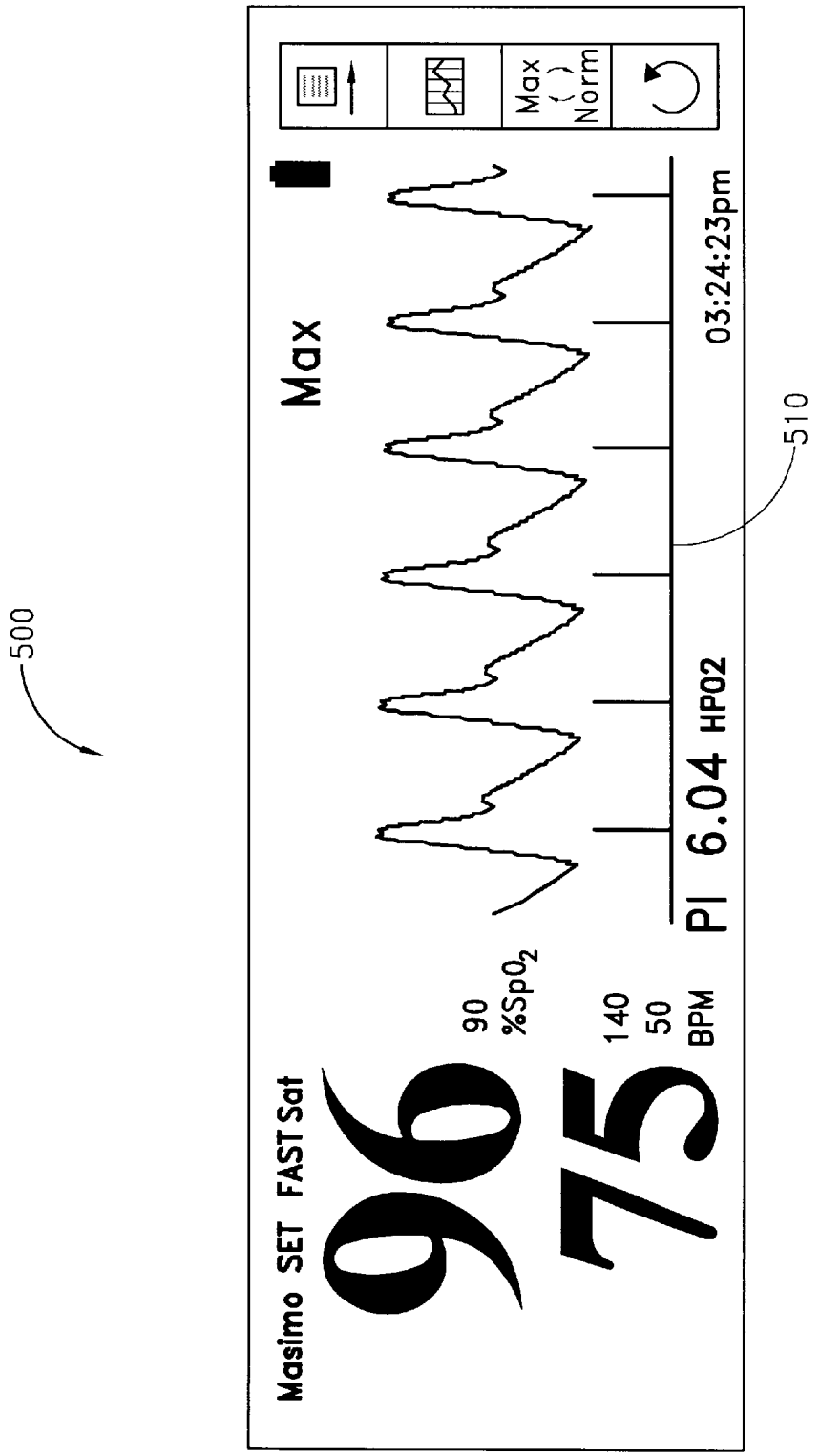

500
Masimo SET FAST Sat
96
90
%SpO2
75
140
50
BPM
PI 6.04 HP02
Max
Max
Norm
03:24:23pm
510

FIG. 5A

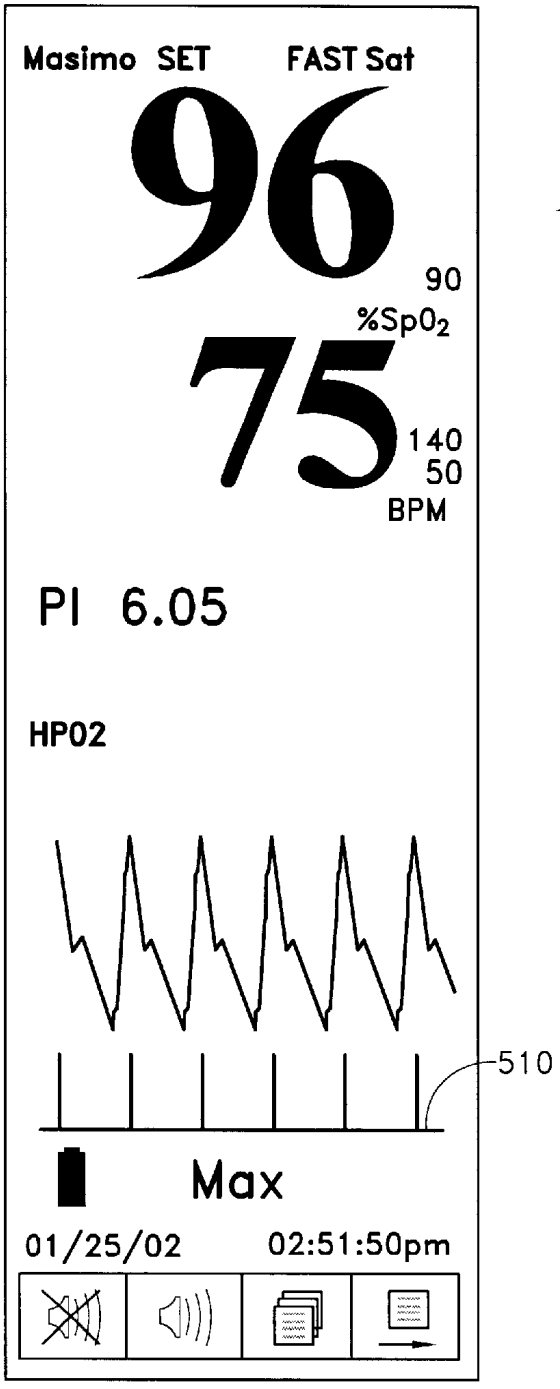

Masimo SET
FAST Sat
96
90
%SpO2
75
140
50
BPM
PI 6.05
HP02
500
510
Max
01/25/02
02:51:50pm

FIG. 5B

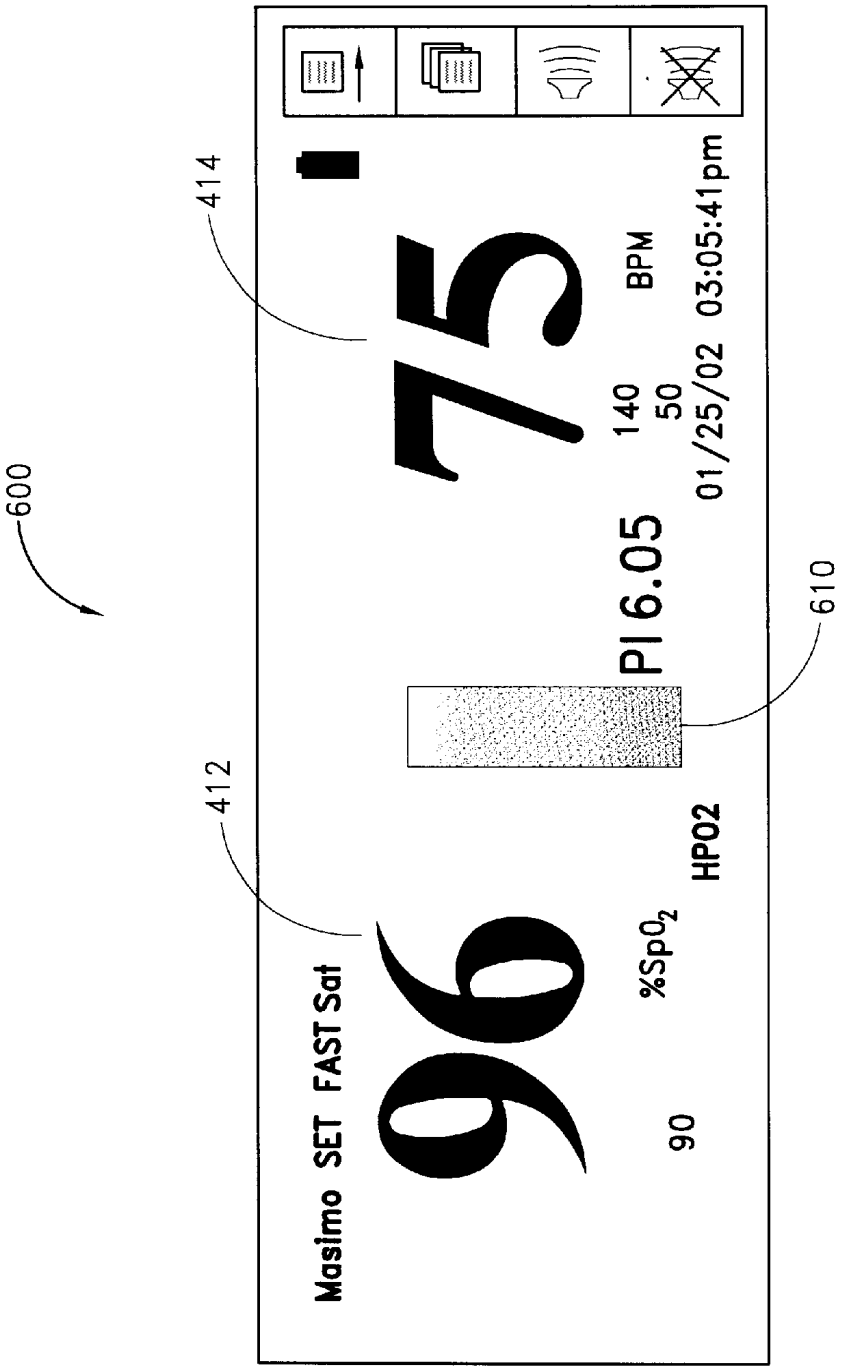

600
414
412
610
75
BPM
140
50
01/25/02 03:05:41pm
PI 6.05
HP02
%SpO2
90
96
Masimo SET FAST Sat

FIG. 6

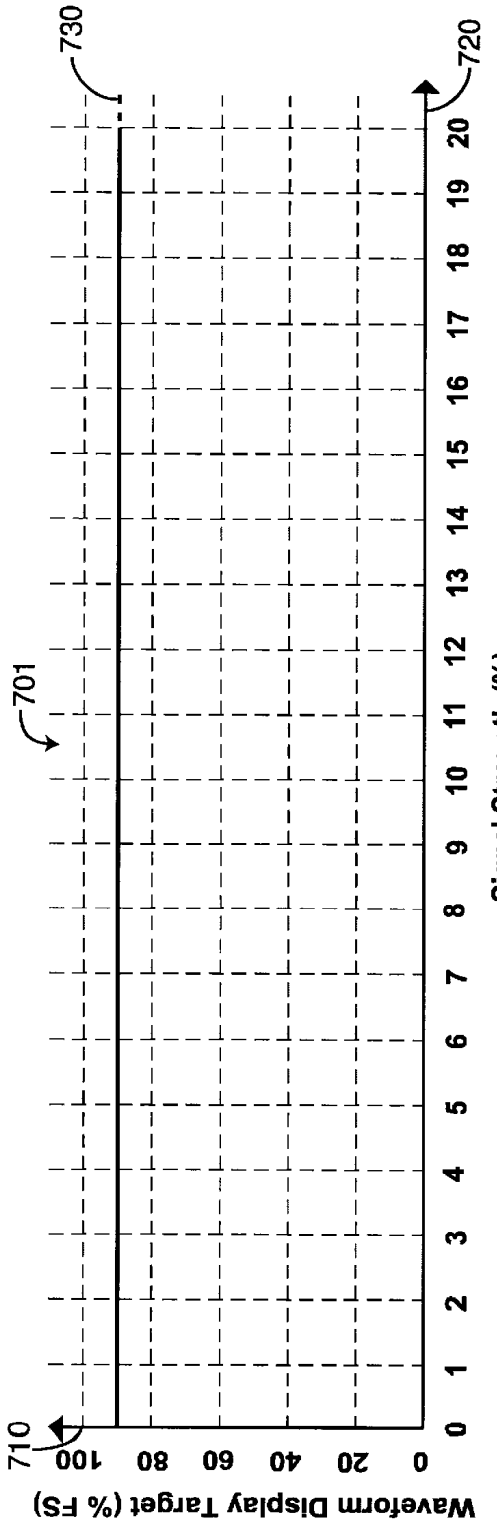

730
720
701
710
Signal Strength (%)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Waveform Display Target (% FS)
0 20 40 60 80 100

FIG. 7A

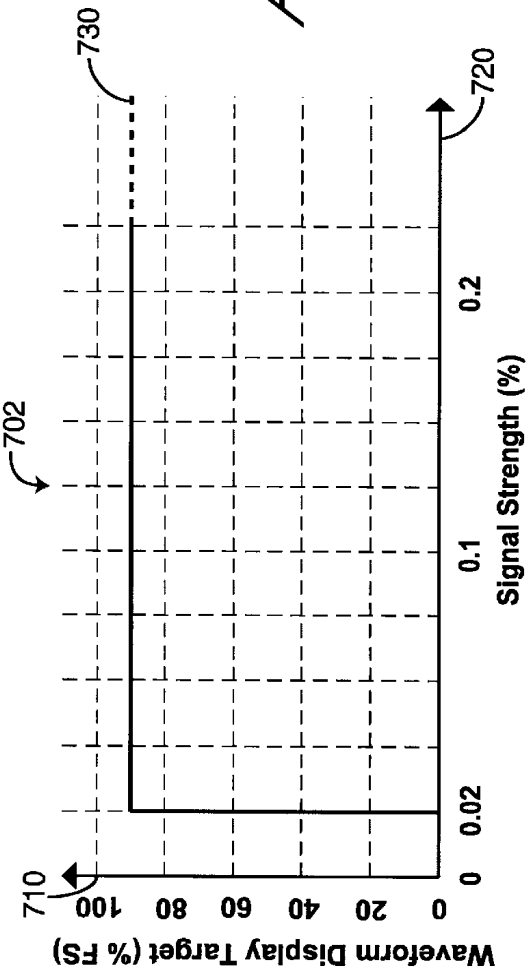

730
720
702
710
Signal Strength (%)
0 0.02 0.1 0.2
Waveform Display Target (% FS)
0 20 40 60 80 100

FIG. 7B

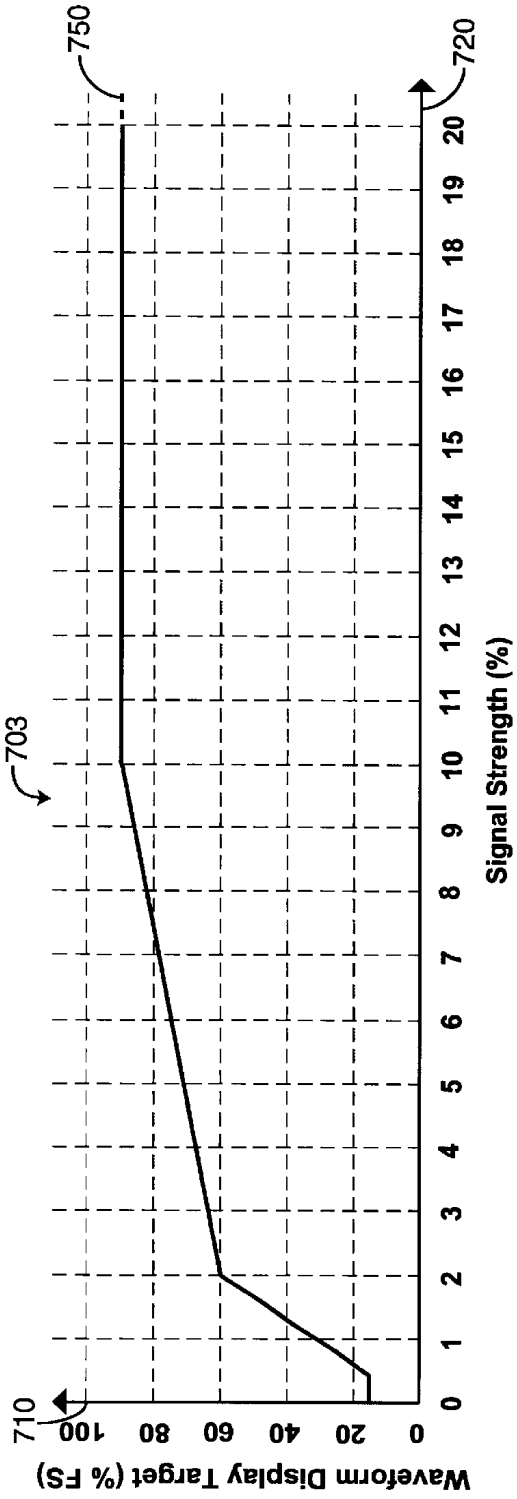

750
720
703
710
Waveform Display Target (% FS)
0 20 40 60 80 100
Signal Strength (%)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

FIG. 7C

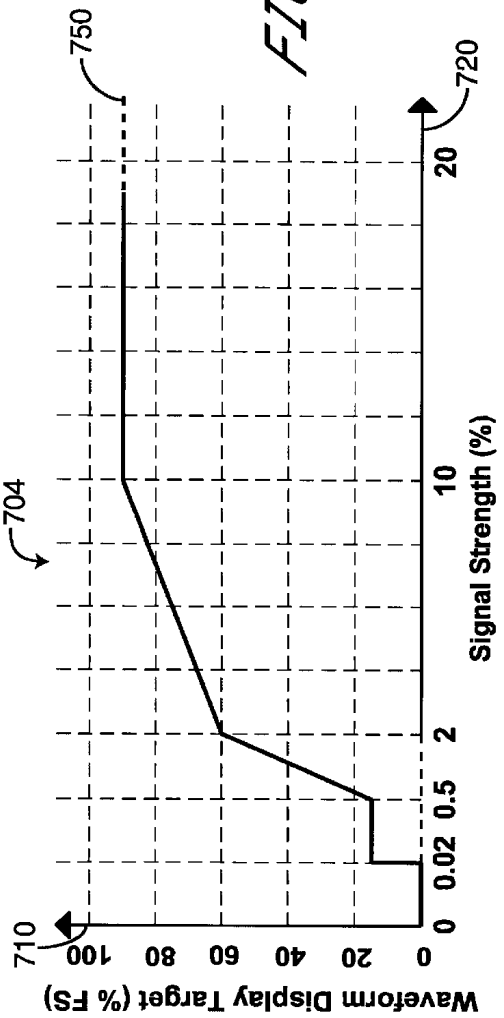

750
720
704
710
Waveform Display Target (% FS)
0 20 40 60 80 100
Signal Strength (%)
0 0.02 0.5 2 10 20

FIG. 7D

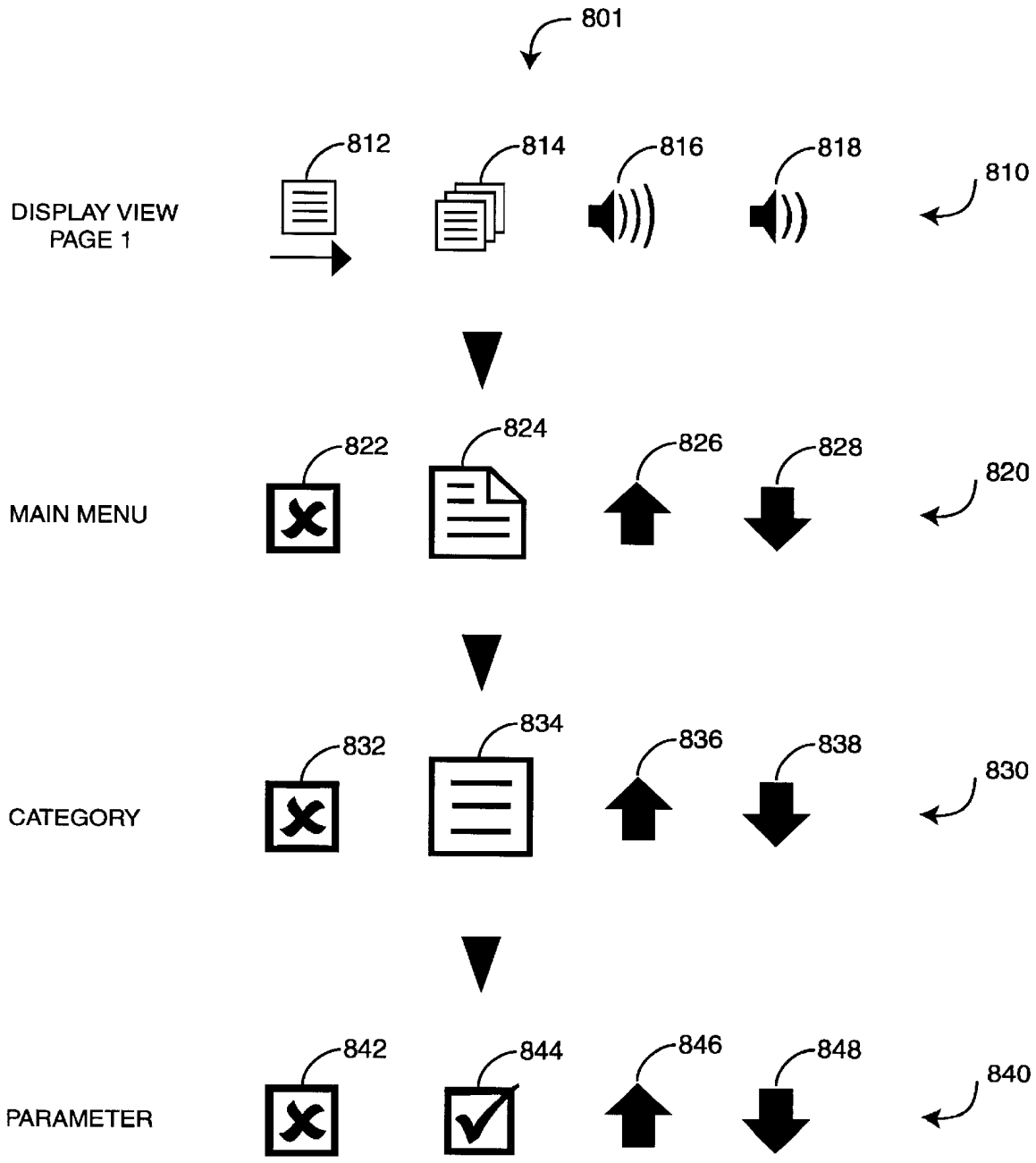

801
812
814
816
818
810
DISPLAY VIEW
PAGE 1
822
824
826
828
820
MAIN MENU
832
834
836
838
830
CATEGORY
842
844
846
848
840
PARAMETER

FIG. 8A

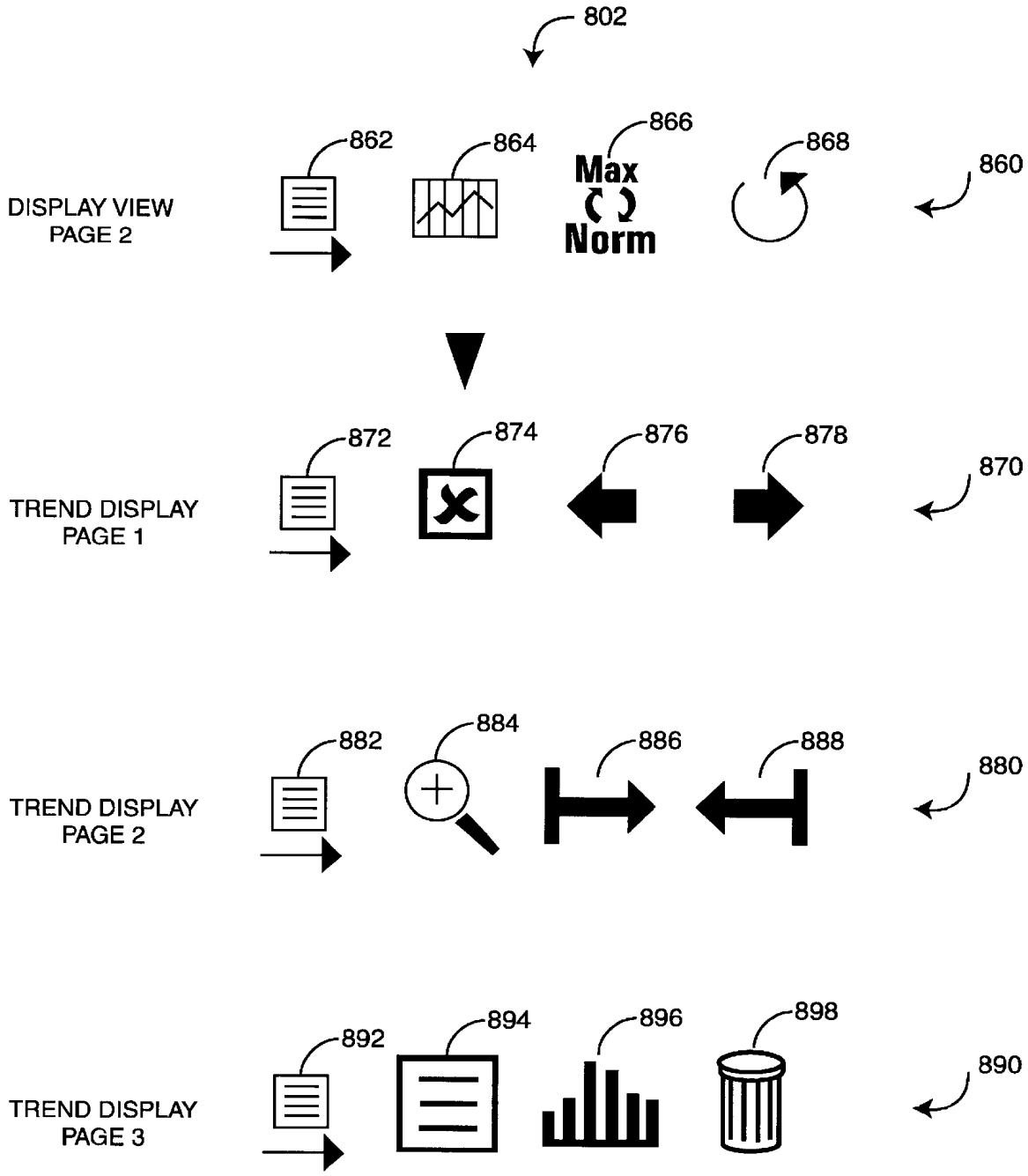

802
DISPLAY VIEW PAGE 2
862
864
866
Max
Norm
868
860
TREND DISPLAY PAGE 1
872
874
876
878
870
TREND DISPLAY PAGE 2
882
884
886
888
880
TREND DISPLAY PAGE 3
892
894
896
898
890

FIG. 8B

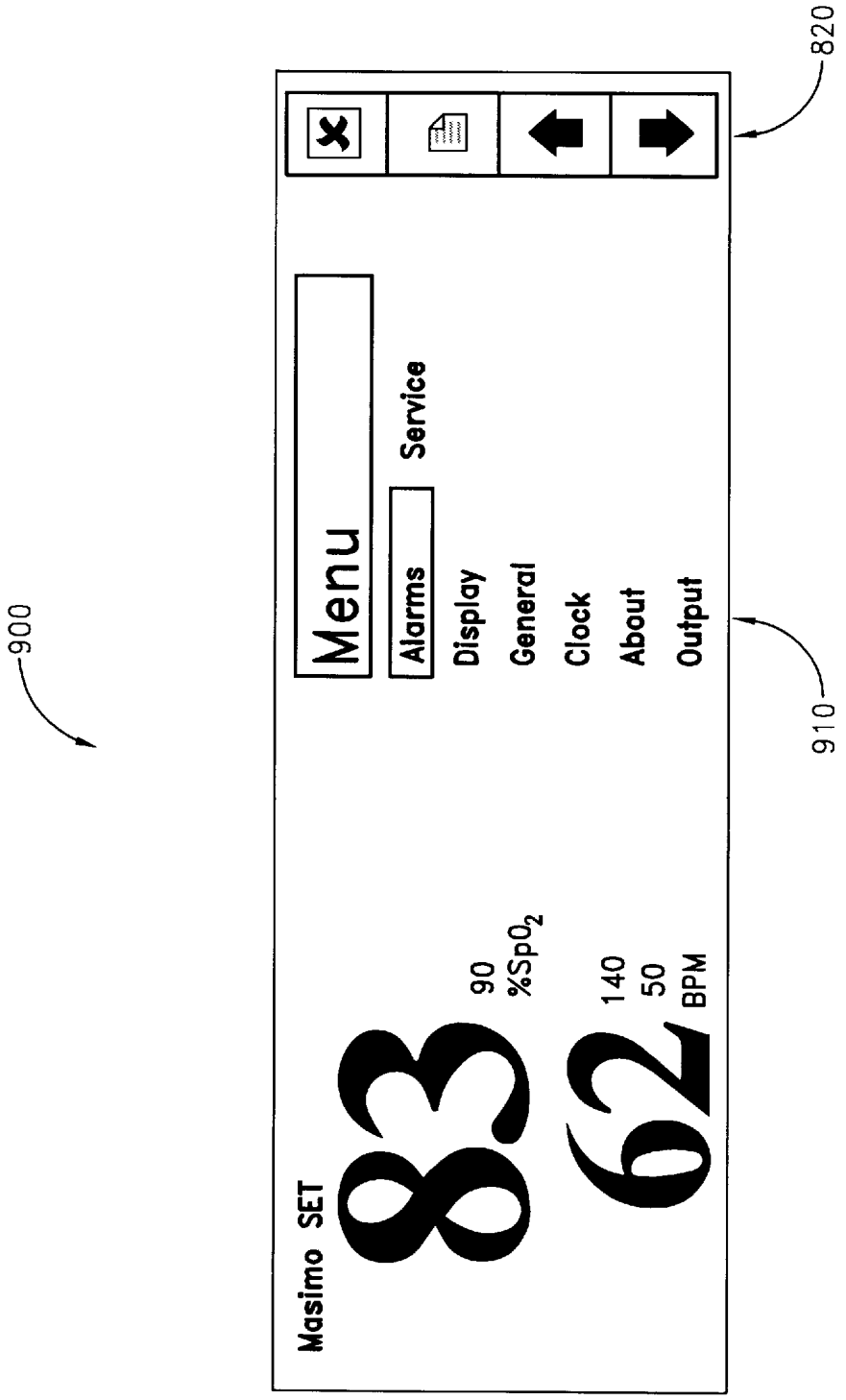

900
820
910
Menu
Alarms
Service
Display
General
Clock
About
Output
Masimo SET
83
90
%SpO2
62
140
50
BPM

FIG. 9A

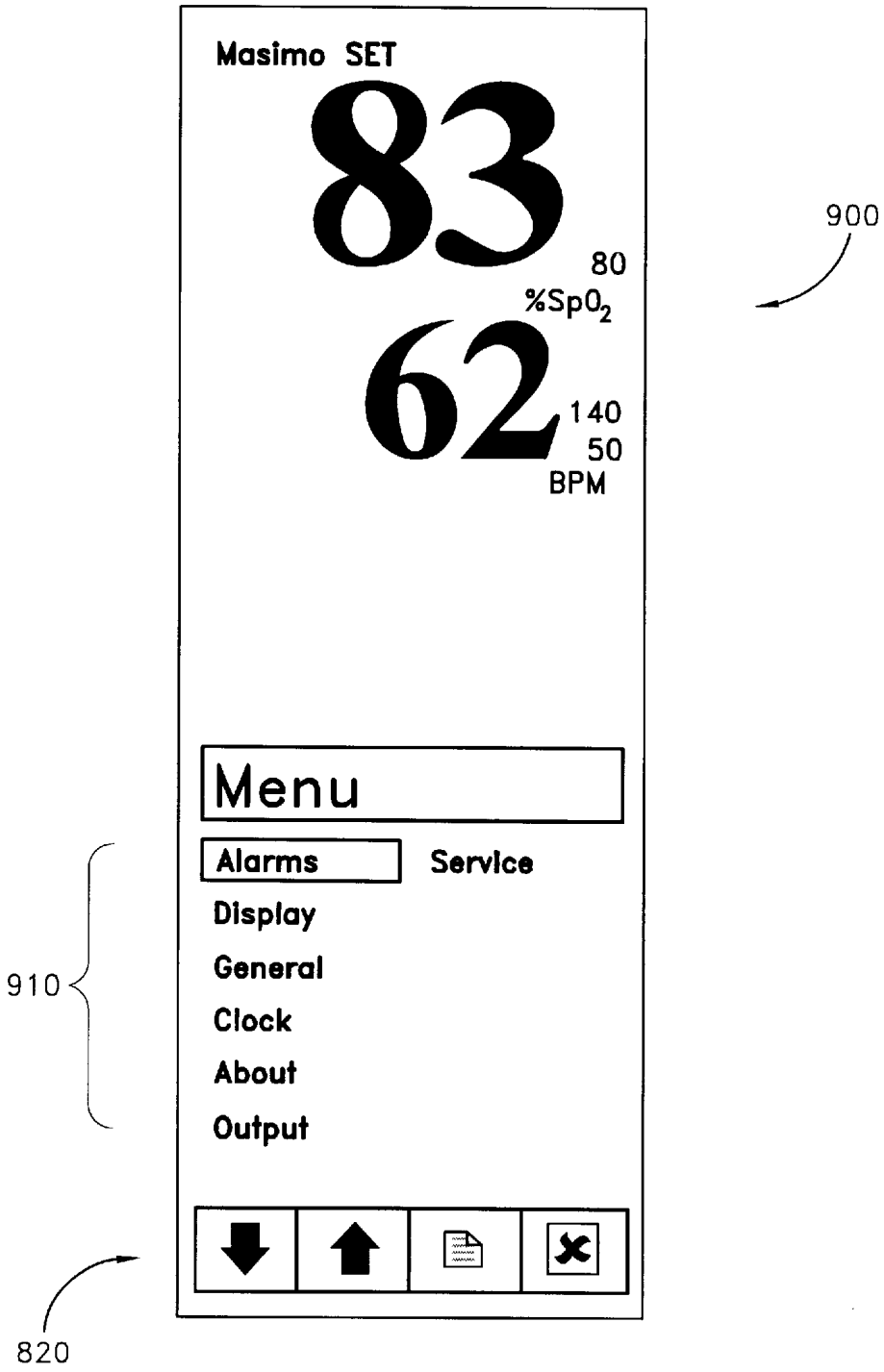

Masimo SET
83
80
%SpO2
62
140
50
BPM
900
Menu
Alarms
Service
Display
General
Clock
About
Output
910
820

FIG. 9B

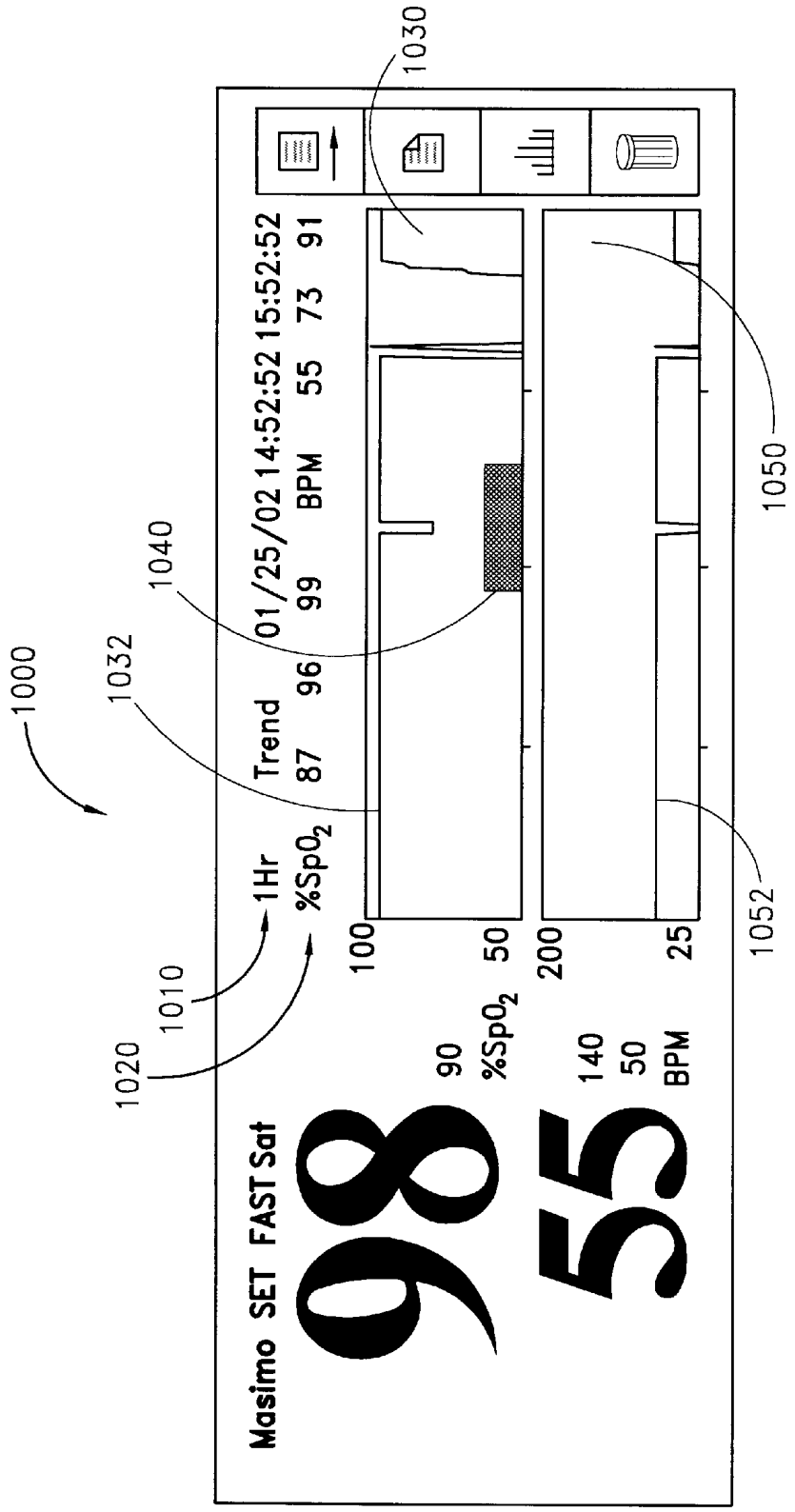

1000
1010
1020
1030
1032
1040
1050
1052
Masimo SET FAST Sat
98
55
%SpO2
BPM
90
140
50
100
50
200
25
1Hr
Trend
01/25/02 14:52:52 15:52:52
99 96 87
BPM 55 73 91

FIG. 10

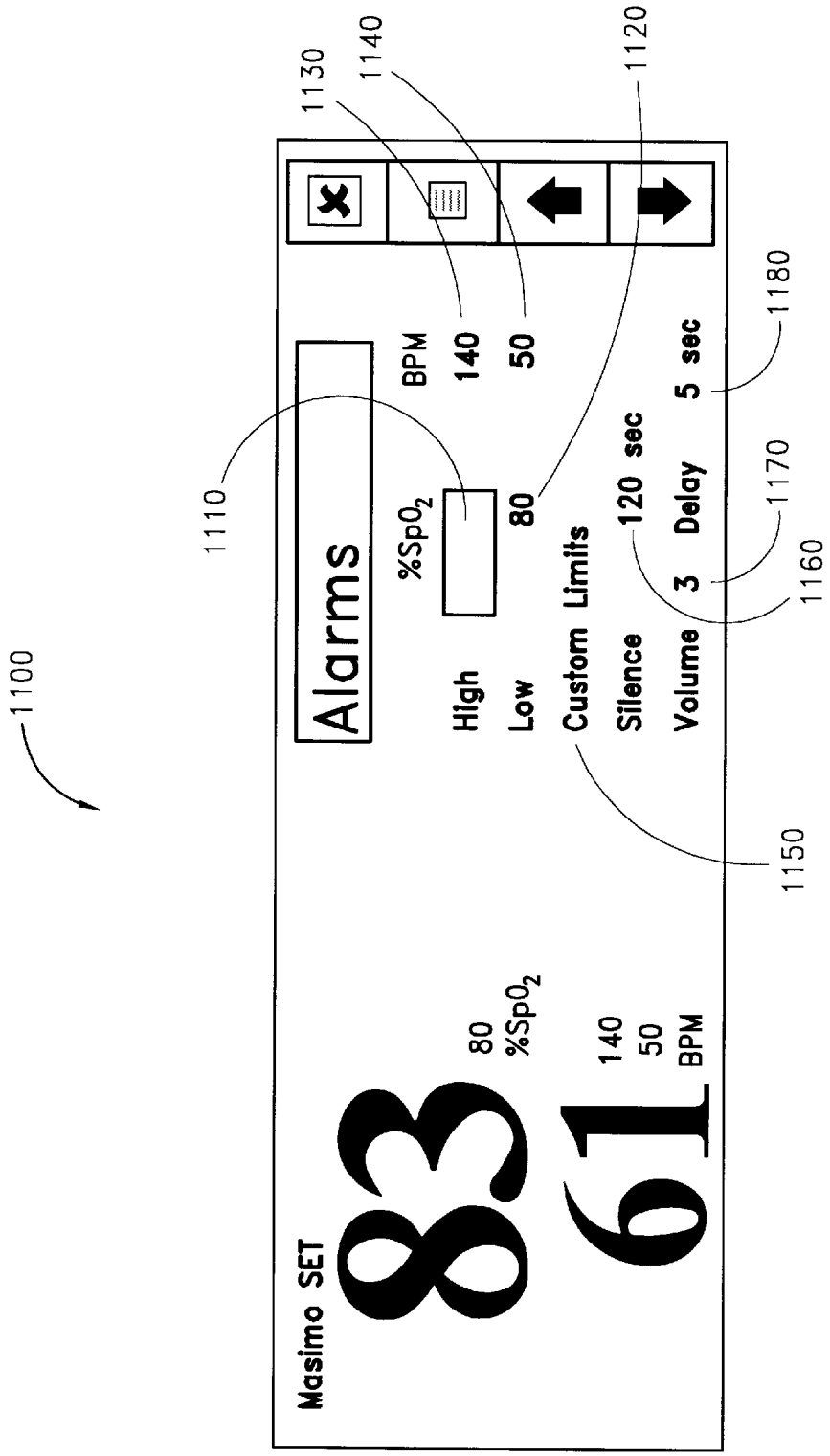

1100
1110
1120
1130
1140
1150
1160
1170
1180
Alarms
%SpO2
BPM
High
Low
140
50
80
Custom Limits
Silence
120 sec
Volume
3
Delay
5 sec
Masimo SET
83
%SpO2
80
61
BPM
140
50

FIG. 11A

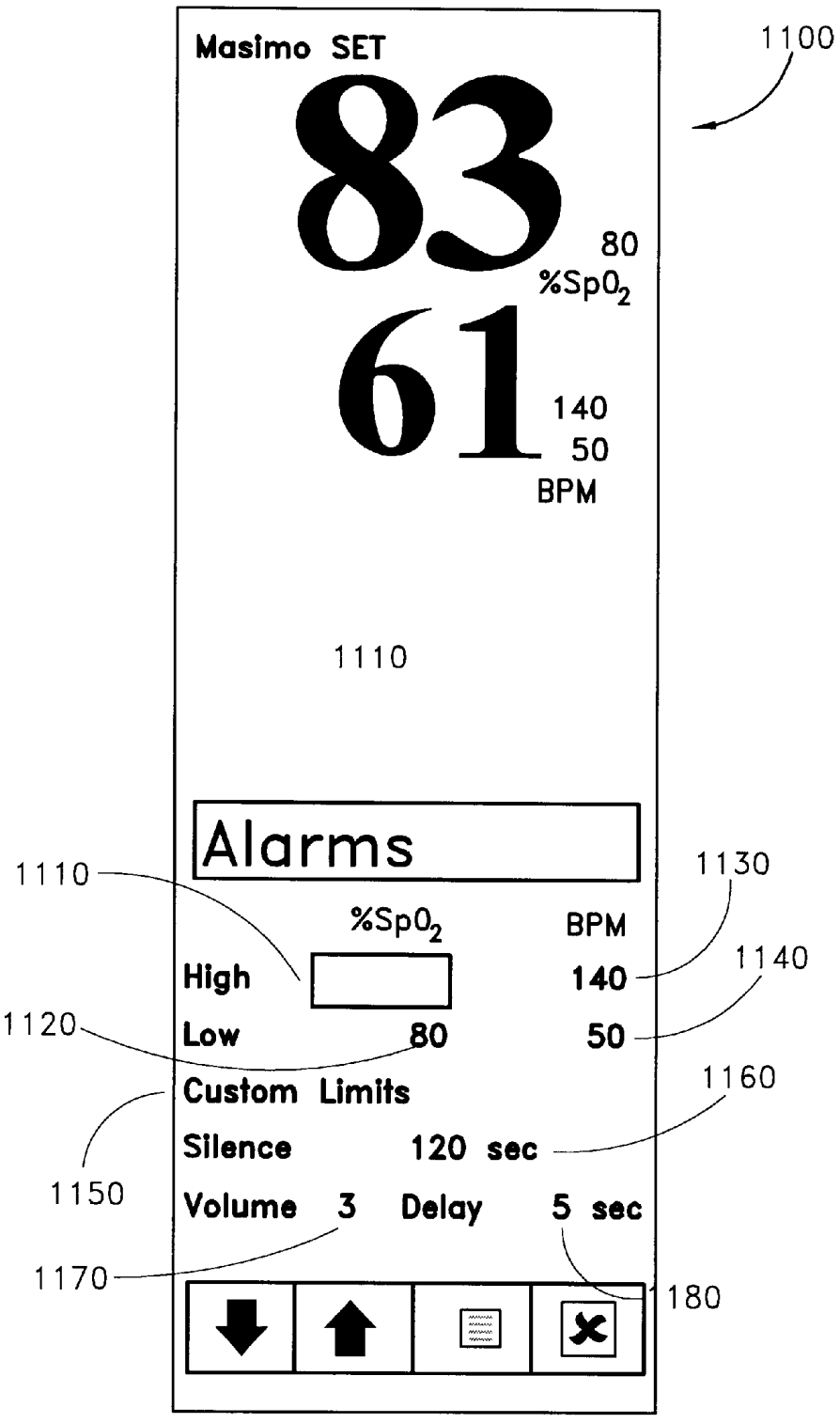

Masimo SET
83
80
%SpO2
61
140
50
BPM
1100
1110
Alarms
1110
%SpO2
BPM
1130
High
140
1140
1120
Low
80
50
Custom Limits
1160
Silence
120 sec
1150
Volume
3
Delay
5 sec
1170
180

FIG. 11B

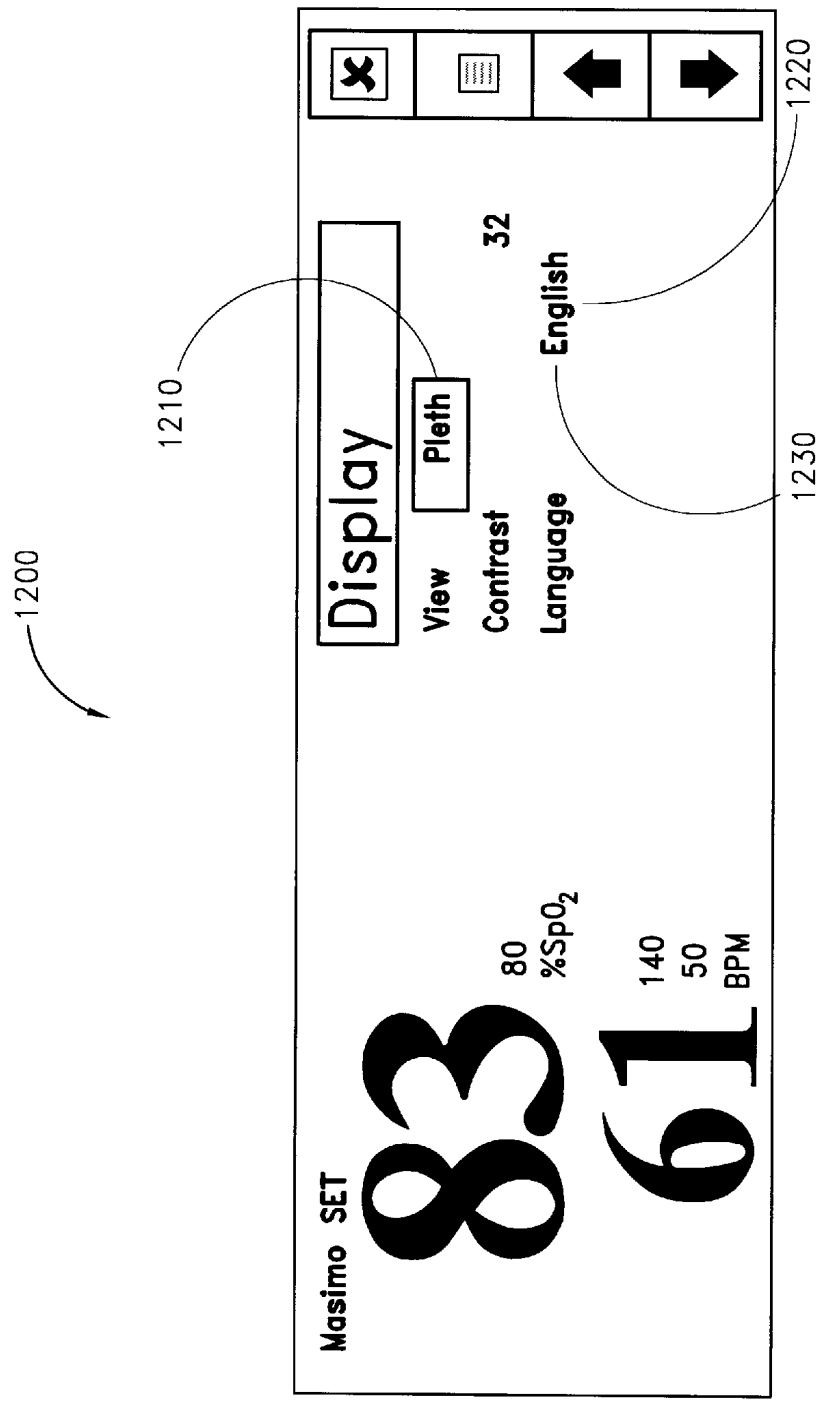

1200
1210
1220
1230
Masimo SET
83
80
%SpO2
61
140
50
BPM
Display
View
Pleth
Contrast
32
Language
English

FIG. 12

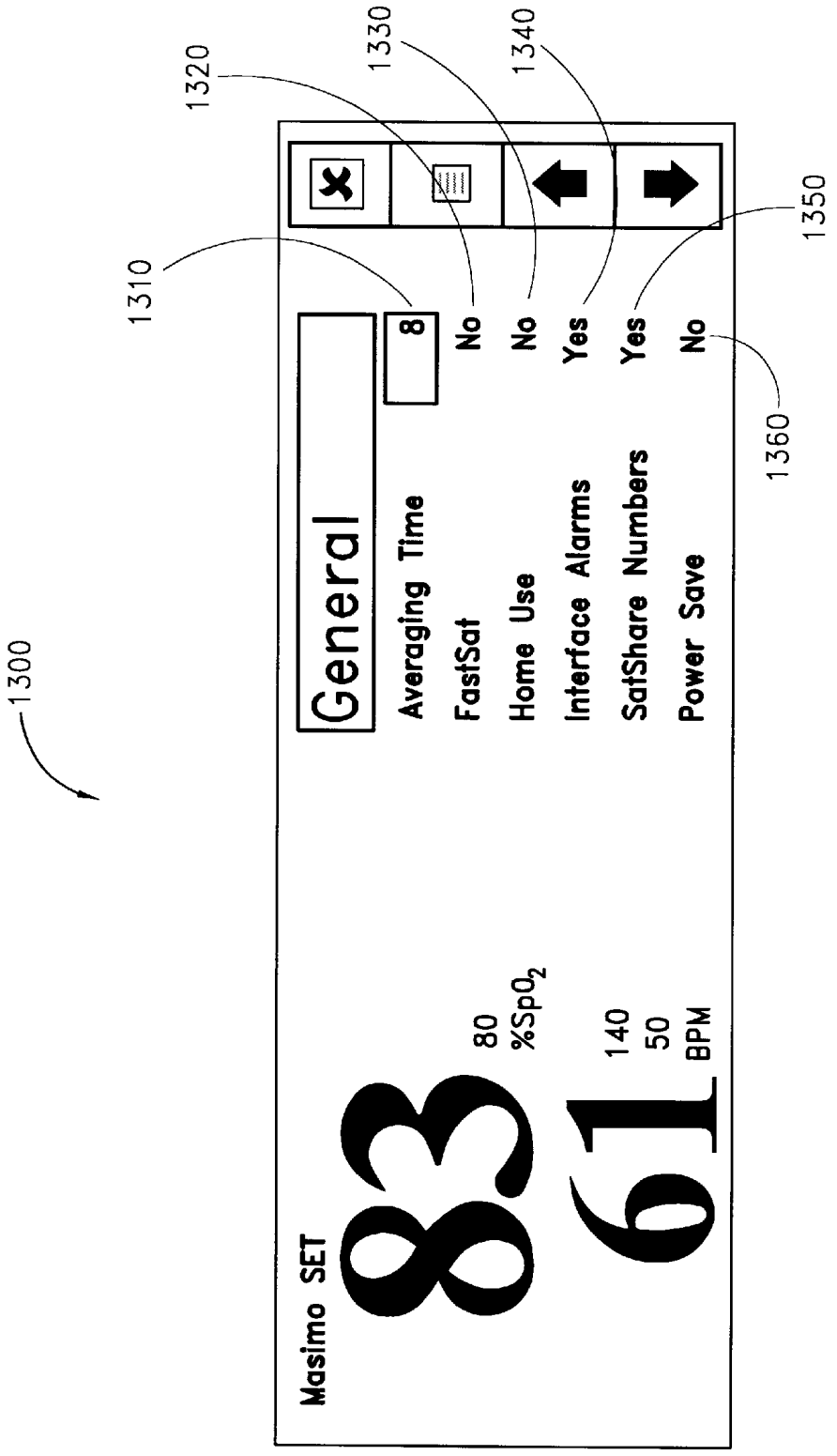

1300
1310
1320
1330
1340
1350
1360
Masimo SET
83
80
%SpO2
61
140
50
BPM
General
Averaging Time
FastSat
Home Use
Interface Alarms
SatShare Numbers
Power Save
8
No
No
Yes
Yes
No

FIG. 13

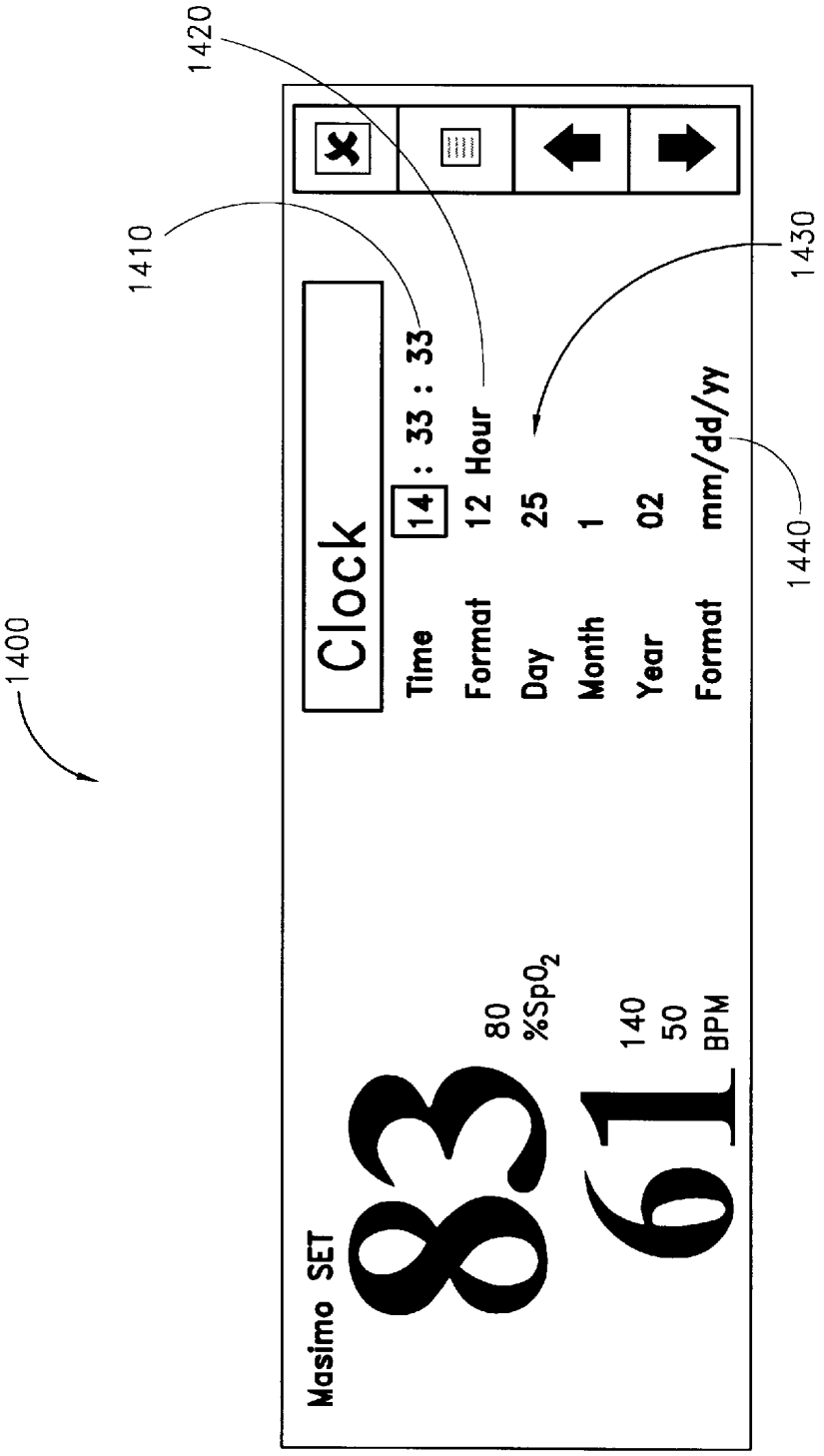

1400
1410
1420
1430
1440
Clock
Time
14 : 33 : 33
Format
12 Hour
Day
25
Month
1
Year
02
Format
mm/dd/yy
Masimo SET
83
80
%SpO2
61
140
50
BPM

FIG. 14

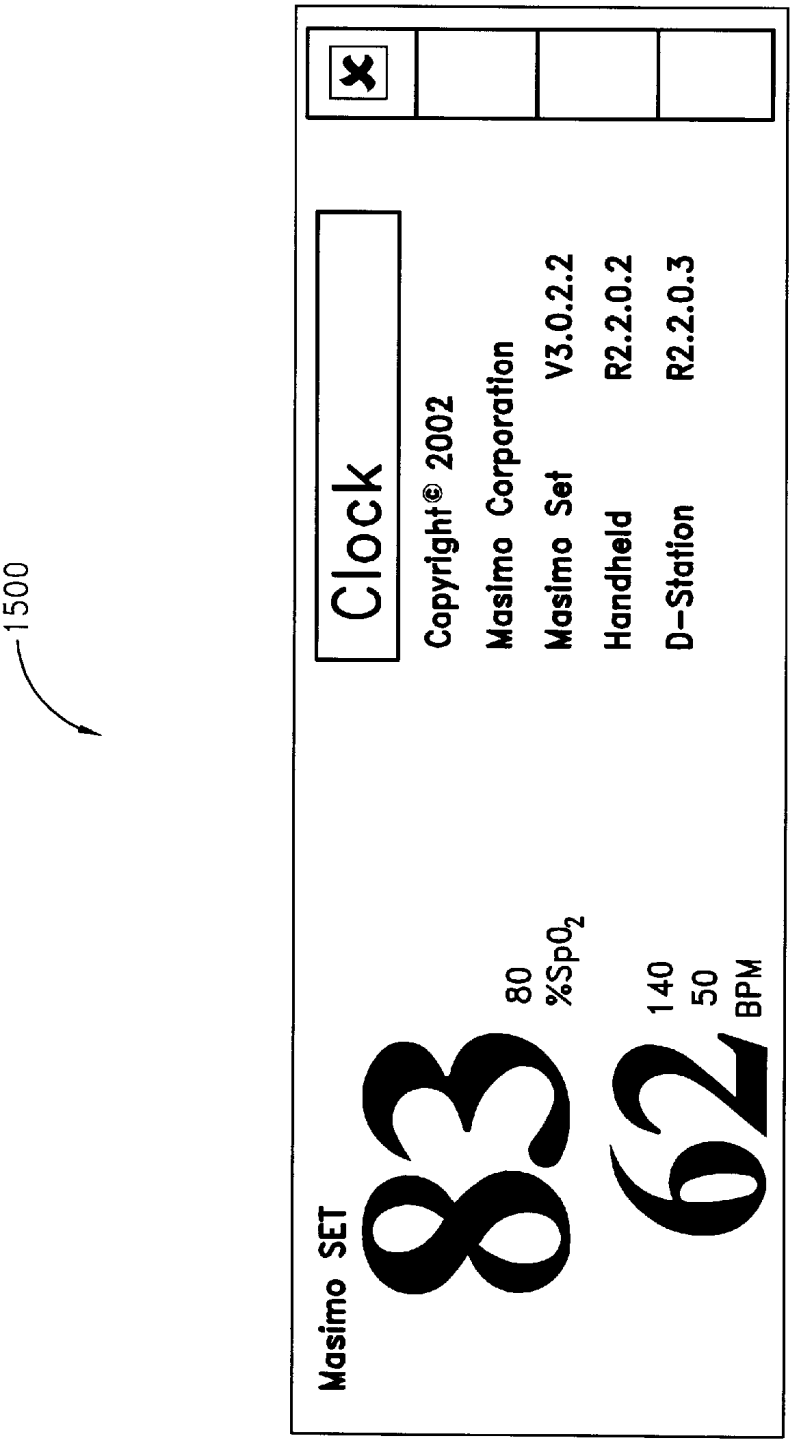

1500
Masimo SET
83
80
%SpO2
62
140
50
BPM
Clock
Copyright© 2002
Masimo Corporation
Masimo Set V3.0.2.2
Handheld R2.2.0.2
D-Station R2.2.0.3

FIG. 15

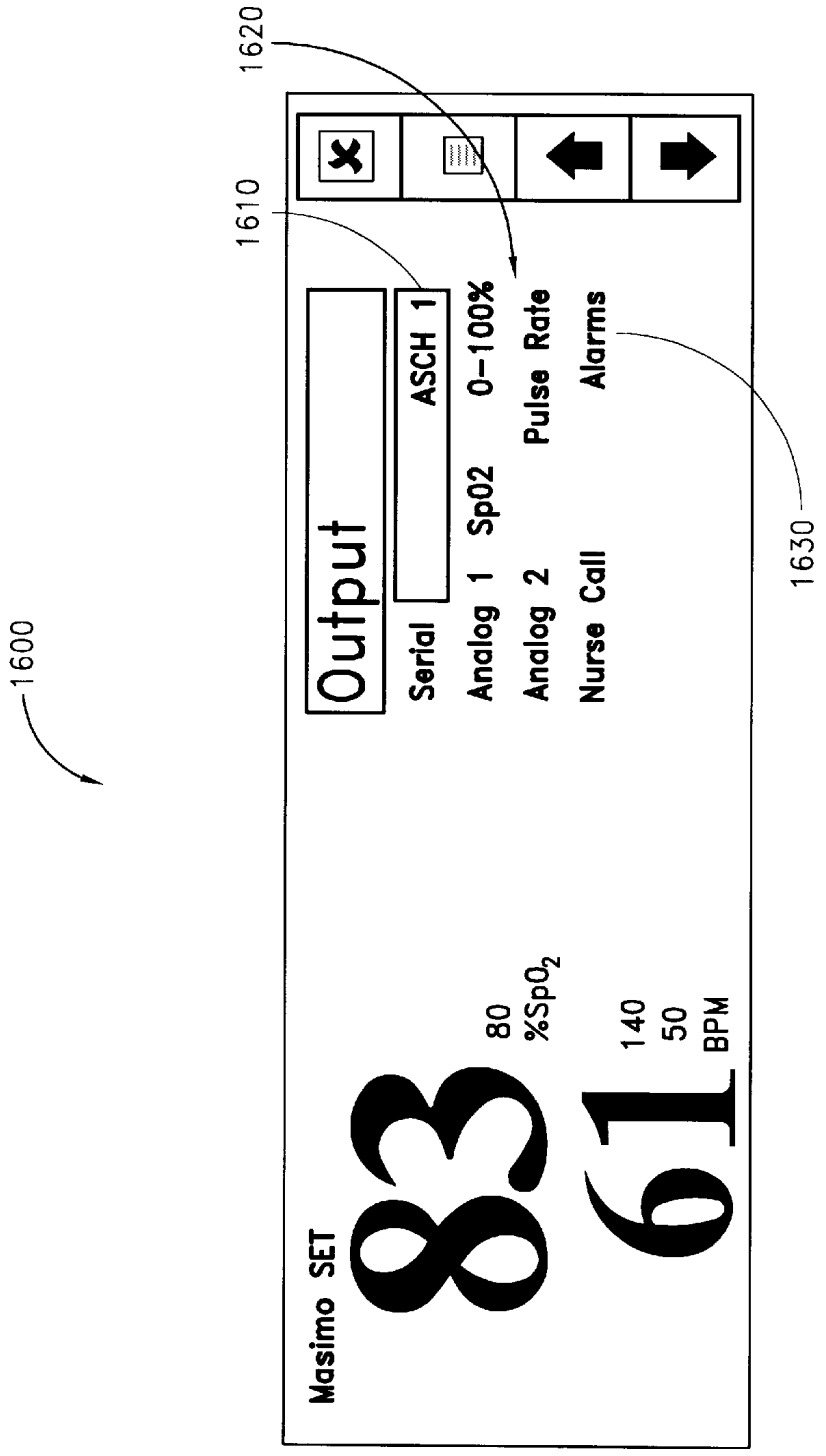

1600
1620
1610
1630
Output
Serial
ASCH 1
Analog 1 Sp02 0-100%
Analog 2 Pulse Rate
Nurse Call Alarms
Masimo SET
83
80
%SpO2
61
140
50
BPM

FIG. 16

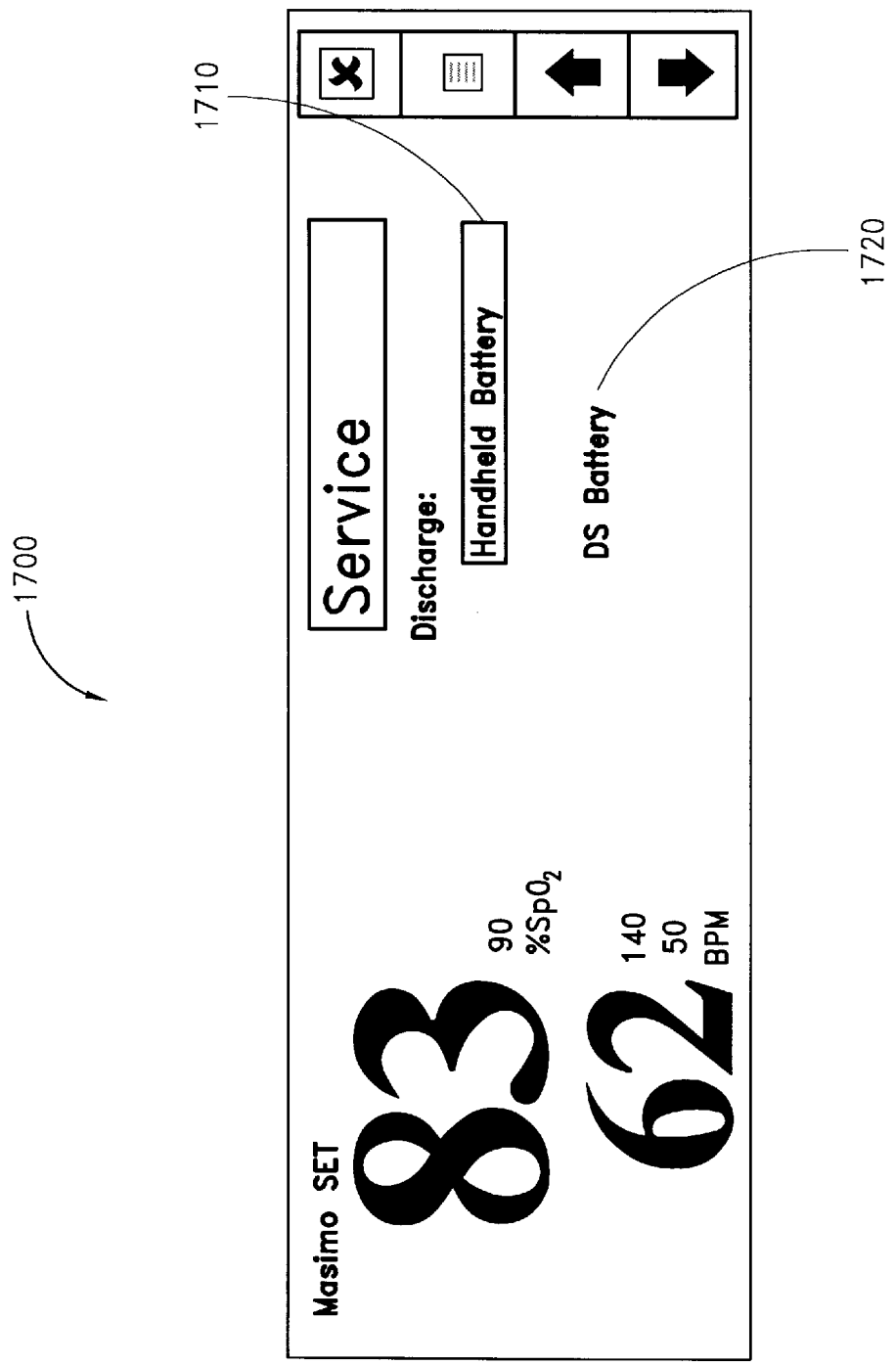

1700
1710
1720
Service
Discharge:
Handheld Battery
DS Battery
Masimo SET
83
90
%SpO2
62
140
50
BPM

FIG. 17

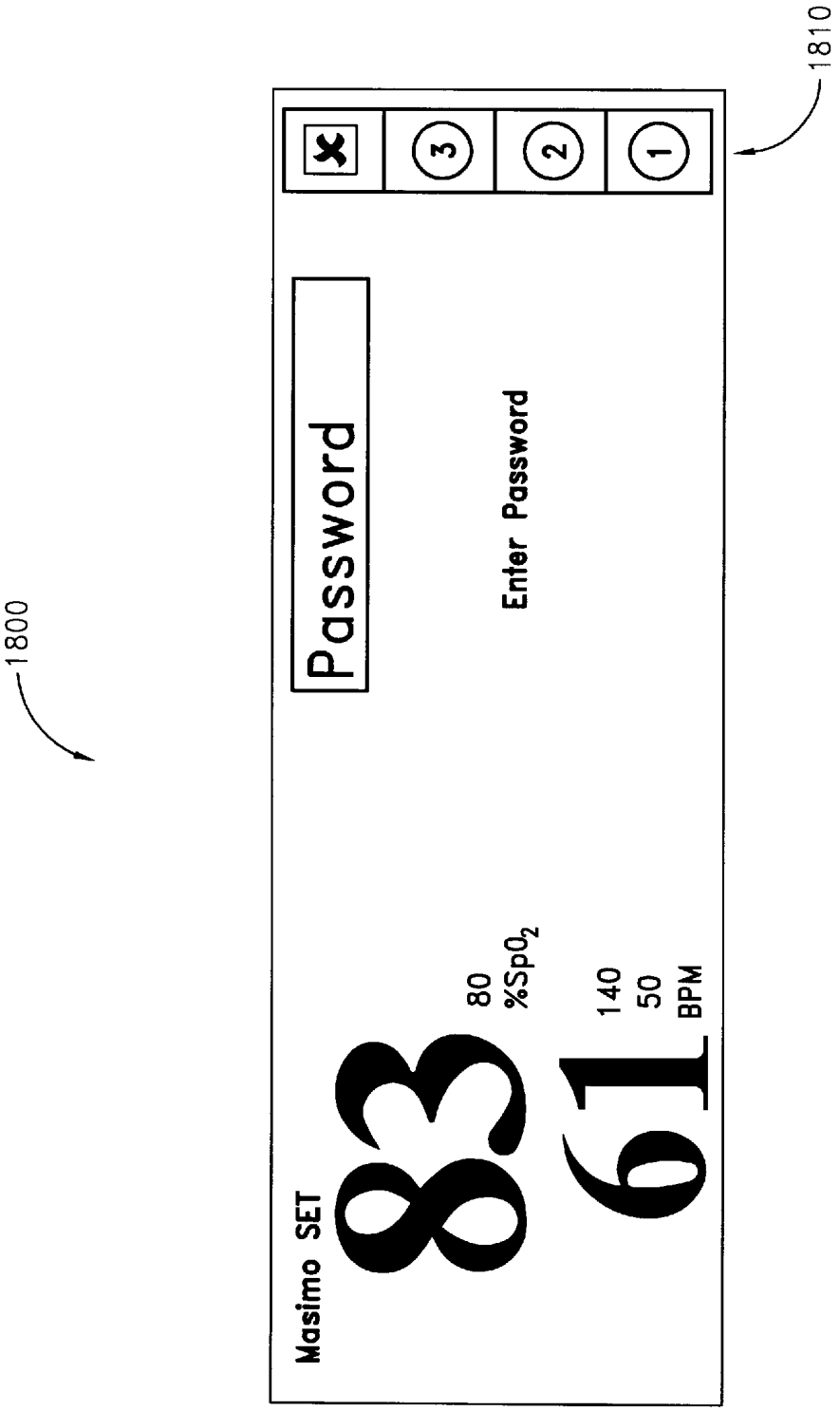

1800
1810
3
2
1
Password
Enter Password
Masimo SET
83
80
%SpO2
61
140
50
BPM

FIG. 18

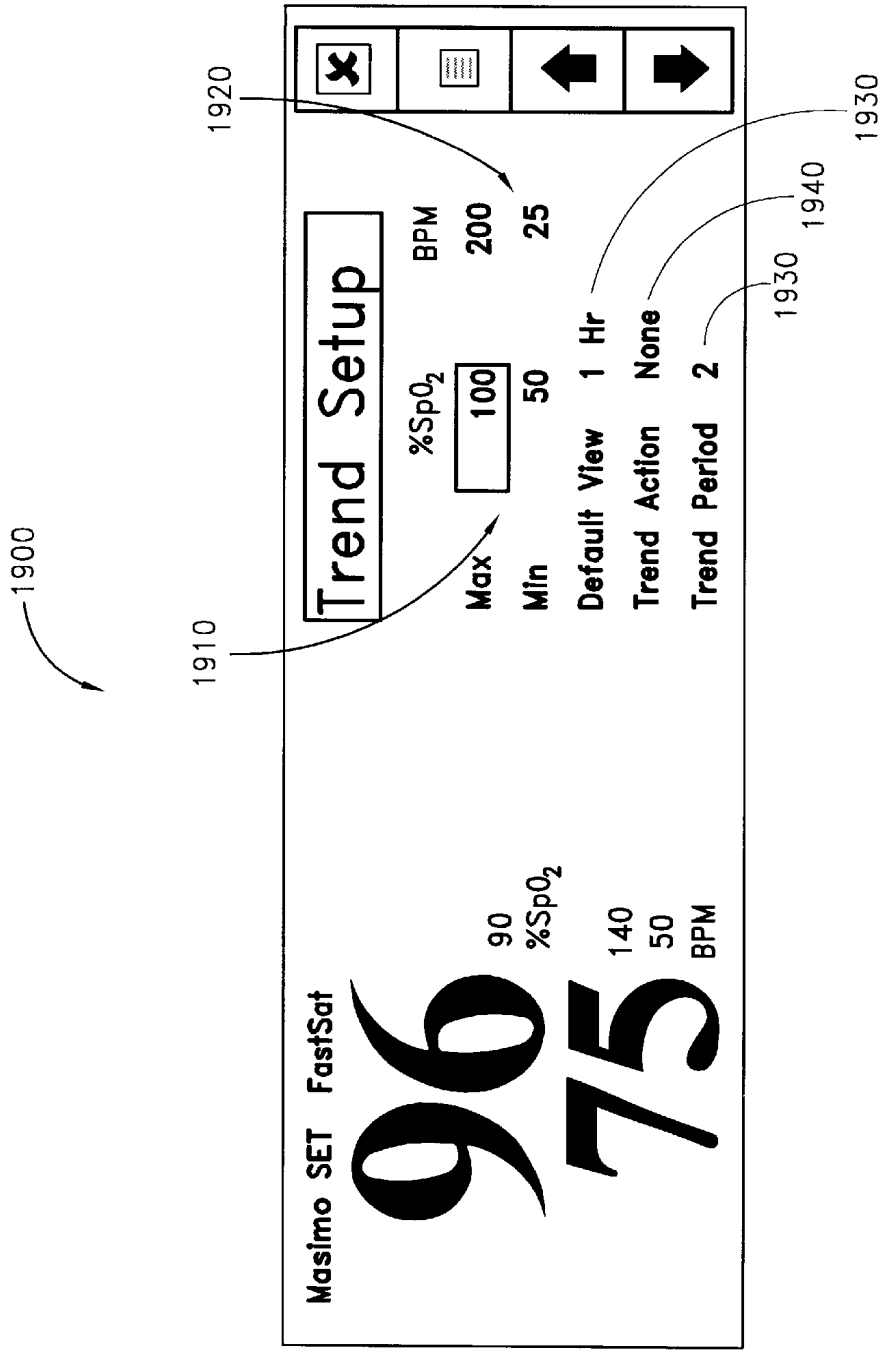

1900
1910
1920
1930
1940
1930
Trend Setup
BPM
200
25
%SpO2
100
Max
50
Min
Default View 1 Hr
Trend Action None
Trend Period 2
Masimo SET FastSat
96
90
%SpO2
75
140
50
BPM

FIG. 19

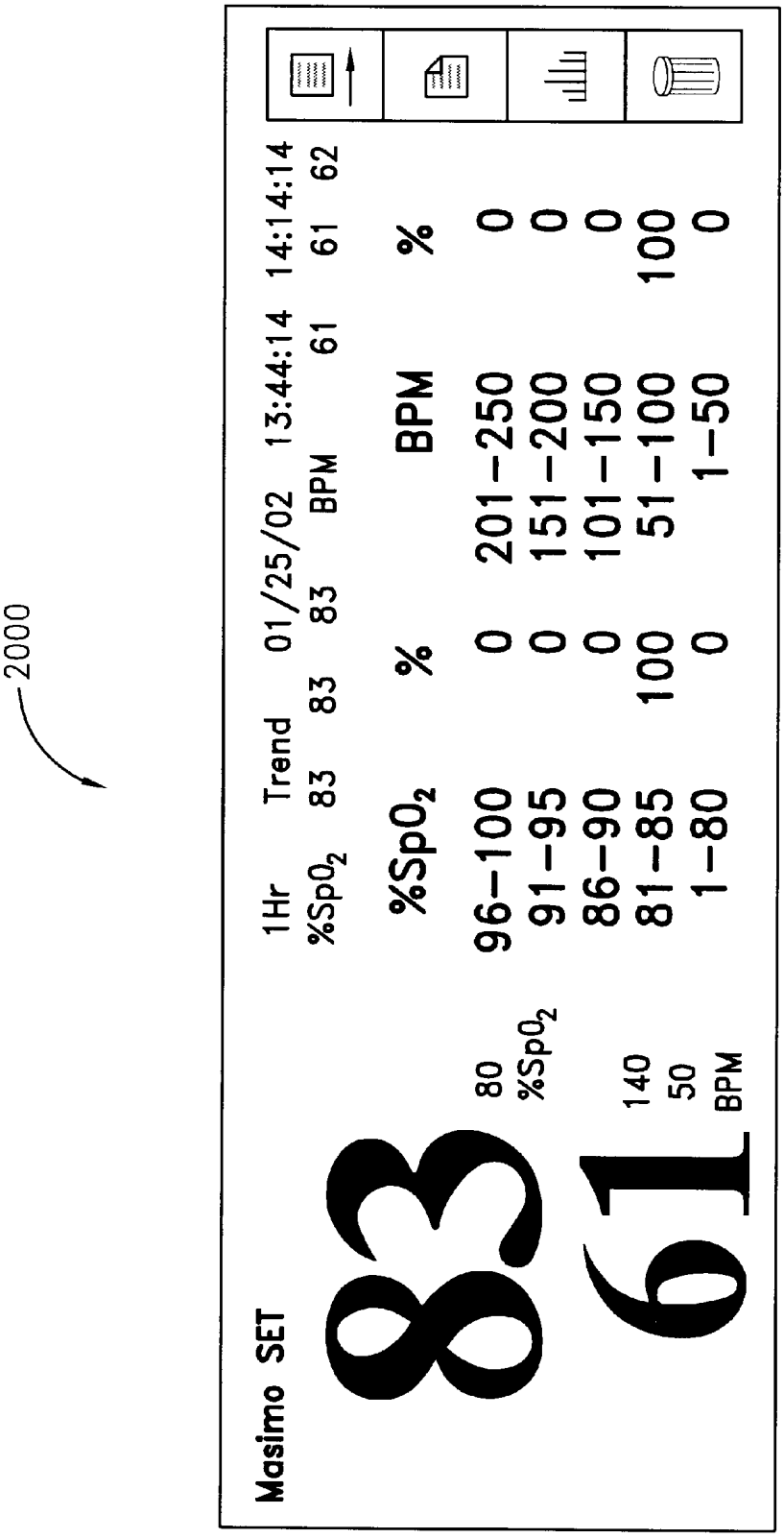

2000
Masimo SET
83
61
80
%SpO2
140
50
BPM
1Hr Trend 01/25/02 13:44:14 14:14:14
%SpO2 83 83 83 BPM 61 61 62
%SpO2 % BPM %
96–100 0 201–250 0
91–95 0 151–200 0
86–90 0 101–150 0
81–85 100 51–100 100
1–80 0 1–50 0

FIG. 20

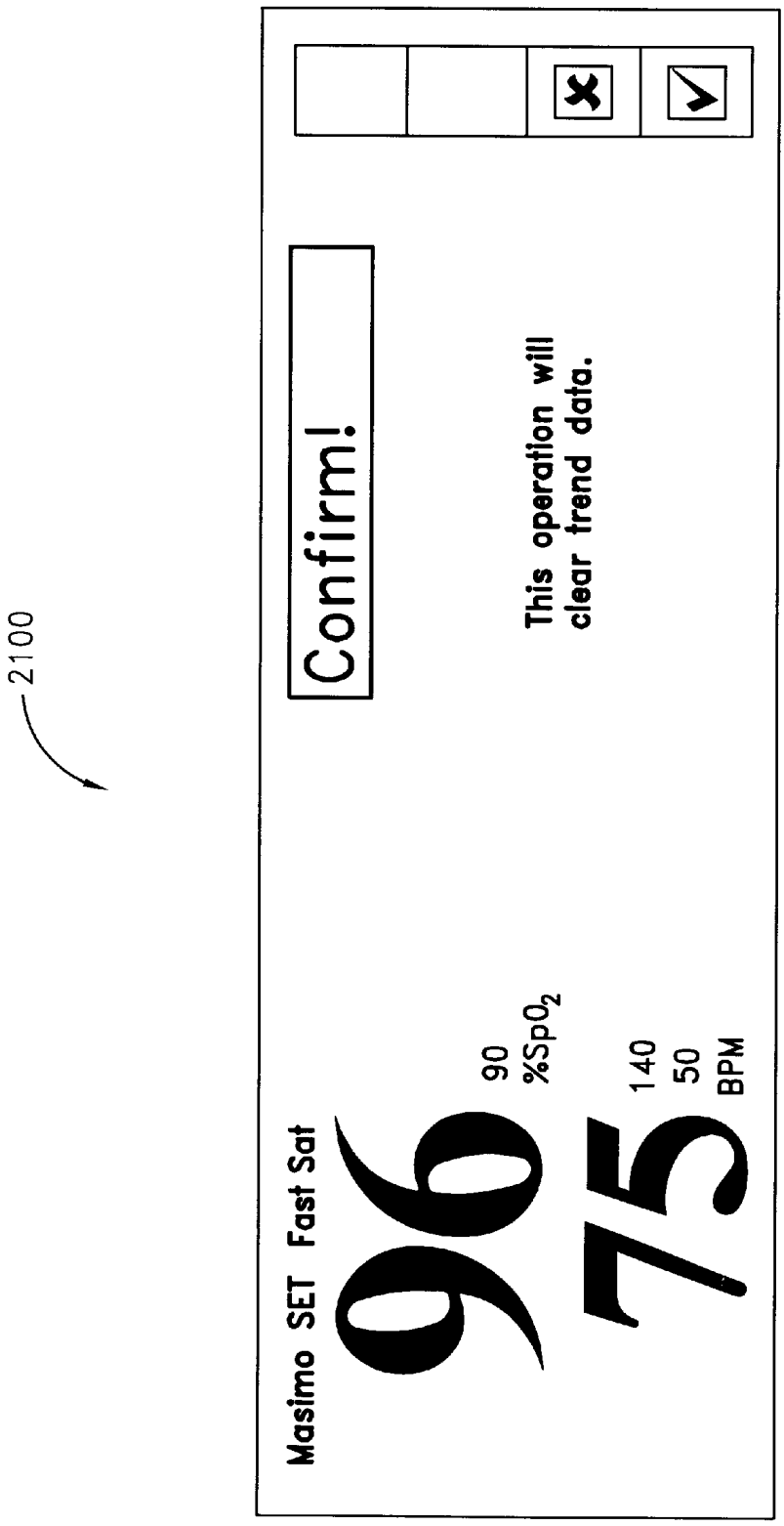

2100
Masimo SET Fast Sat
96
90
%SpO2
75
140
50
BPM
Confirm!
This operation will clear trend data.

FIG. 21

PULSE OXIMETER USER INTERFACE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims a priority benefit under 35 U.S.C. §120 from, and is a continuation-in-part of U.S. patent application Ser. No. 09/641,542, filed Aug. 18, 2000, entitled "Dual-Mode Pulse Oximeter," No. 09/516,110, filed Mar. 1, 2000, now U.S. Pat. No. 6,584,336 entitled "Universal/Upgrading Pulse Oximeter," and No. 09/491, 175, filed Jan. 25, 2000 now ABN, entitled "Universal/ Upgrading Pulse Oximeter." This application also claims a priority benefit under 35 U.S.C. §119(e) from U.S. Provisional Patent Application No. 60/268,207, filed Feb. 12, 2001, entitled "Pulse Oximetry User Interface," No. 60/161, 565, filed Oct. 26, 1999, entitled "Improved Universal/ Upgrading Pulse Oximeter, and No. 60/117,097, filed Jan. 25, 1999, entitled "Universal/Upgrading Pulse Oximeter." Each of the foregoing applications are incorporated by reference herein. For reference, the '542 patent application is also a continuation-in-part of the '175 patent application, the '110 patent application is a continuation of the '175 patent application, and the '175 patent application claims priority to the '565 and '097 provisional patent applications.

BACKGROUND OF THE INVENTION

Pulse oximetry is a continuous and non-invasive method of measuring the level of arterial oxygen saturation in blood. The measurement is taken by placing a sensor on a patient, usually on the fingertip for adults and the hand or foot for neonates. The sensor is connected to a pulse oximetry instrument with a patient cable. The sensor collects signal data from the patient and sends it to the instrument. A pulse oximetry instrument typically displays the calculated data as a percent value for arterial oxygen saturation (SpO_2), as a pulse rate (PR) and as a plethysmographic waveform.

Pulse oximetry is governed by a several principles. Oxyhemoglobin (oxygenated blood) and deoxyhemoglobin (non-oxygenated blood) differ in their absorption of red and infrared light (spectrophotometry). Also, the amount of arterial blood in tissue changes with an arterial pulse (photoplethysography). Therefore, the amount of light absorbed by the varying quantities of arterial blood changes as well.

A typical pulse oximeter uses a two-wavelength pulsatile system to distinguish between oxygenated and deoxygenated blood. Signal data is obtained by passing red and infrared light through a capillary bed (for example a fingertip, a hand, a foot) and measuring changes in light absorption during the pulsatile cycle. A typical pulse oximeter utilizes a sensor with red and infrared light-emitting diodes (LEDs) that pass light through the site to a photodiode (photodetector). The photodetector receives the light, converts it into an electronic signal and sends it, via a patient cable, to the pulse oximeter for calculation.

A pulse oximeter measures and displays functional saturation, which is the amount of oxygenated hemoglobin expressed as a percentage of the hemoglobin that can transport oxygen. This is not a measure of fractional saturation, i.e. oxygenated hemoglobin expressed as a percentage of all measured hemoglobin, including measured dysfunctional hemoglobin such as carboxyhemoglobin or methemoglobin.

Oxygen saturation measurements obtained from a pulse oximeter are commonly compared to saturations calculated from the partial pressure of oxygen (PO_2) obtained from an arterial blood gas sample. The calculated value obtained from the blood gas sample, however, may differ from the SpO_2 measurement of the pulse oximeter. Different results are usually obtained from the blood gas sample if the calculated saturation is not appropriately corrected for the effects of variables that shift the relationship between PO_2 and saturation, such as pH, temperature, the partial pressure of carbon dioxide (PCO_2), and fetal hemoglobin. Also, as blood gas samples are usually taken over a period of 20 seconds (the time it takes to draw blood) a meaningful comparison can only be achieved if the core oxygen saturation of the patient is stable and not changing over the period of time that the blood gas sample is taken.

Embodiments of the present invention seeks to overcome some or al of these and other problems.

SUMMARY OF THE INVENTION

One aspect of a pulse oximetry user interface is a display and a plurality of views each configured to occupy at least a portion of the display. Each of the views are adapted to present data responsive to a physiological signal. A plurality of icons are configured to occupy a portion of the views and adapted to designate the content of the views. Further, a plurality of keys are proximate to the display and are associated with or otherwise correspond to the icons such that selection of key corresponds to selection of an icon. One of the views is a pleth view that presents a pulse waveform. Another one of the views is a trend view that presents a trend graph. At least one of the icons can be selected so as to switch the display between the pleth view and the trend view.

Another aspect of a pulse oximetry user interface is a method comprising the steps of deriving a pulse waveform responsive to a physiological signal, calculating a data trend responsive to the physiological signal and providing the pulse waveform in a first display view. Other steps include presenting at least a portion of the data trend in a second display view, selecting a first icon accessible from the first display view to switch to the second display view, and selecting a second icon accessible from the second display view to switch to the first display view.

Yet another aspect of a pulse oximetry user interface is a view means for presenting to a user data responsive to a physiological signal, a main menu means for choosing display related categories, and a category menu means for choosing display related parameters. The parameters determine the characteristic of the view means. The user interface also includes an icon means for designating the view means, accessing the menu means and altering the parameters. The interface further includes a soft key means for selecting the icon means.

For purposes of summarizing the invention, certain aspects, advantages and novel features of the invention have been described herein. Of course, it is to be understood that not necessarily all such aspects, advantages or features will be embodied in any particular embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

A general architecture that implements the various features of the invention will now be described with reference to the drawings. The drawings and the associated descriptions are provided to illustrate embodiments of the invention and not to limit the scope of the invention. Throughout the drawings, reference numbers are re-used to indicate correspondence between referenced elements. In addition, the first digit of each reference number indicates the figure in which the element first appears.

FIGS. **1**A–C are perspective views of a three-in-one pulse oximeter;

FIGS. **2**A–C are illustrations of a pulse oximeter user interface;

FIG. **3** is a hierarchical chart of a pulse oximeter user interface;

FIGS. **4**–**6** are illustrations of display views;

FIG. **4** illustrates a pleth only view;

FIGS. **5**A–B illustrate horizontal and vertical formats, respectively, of a pleth and signal quality view;

FIG. **6** illustrates a numeric view;

FIGS. **7**A–D are graphs of pleth auto-scaling and auto-clipping characteristics;

FIGS. **8**A–B are hierarchical charts of soft key icons;

FIGS. **9**A–B illustrate horizontal and vertical formats, respectively, of a main menu;

FIG. **10** is an illustration of a trend view;

FIGS. **11**–**18** are illustrations of submenus and screens accessible from the main menu;

FIGS. **11**A–B illustrate horizontal and vertical formats, respectively, of an alarm menu;

FIG. **12** is an illustration of a display menu;

FIG. **13** is an illustration of a general menu;

FIG. **14** is an illustration of a clock menu;

FIG. **15** is an illustration of an about screen;

FIG. **16** is an illustration of an output menu;

FIG. **17** is an illustration of a service menu;

FIG. **18** is an illustration of a password screen;

FIGS. **19**–**21** are illustrations of trend-related menus and screens accessible from the trend view;

FIG. **19** is an illustration of a trend setup menu;

FIG. **20** is an illustration of a histogram screen; and

FIG. **21** is an illustration of a clear confirmation screen.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. **1**A–C illustrate an instrument that provides the functionality of three pulse oximeters in one. FIG. **1**A illustrates a full-featured handheld pulse oximeter **101**. FIG. **1**B illustrates a full-featured standalone pulse oximeter **105**. FIG. **1**C illustrates an upgrading pulse oximeter **109**.

As shown in FIG. **1**A, the handheld **101** contains the majority of the pulse oximeter features. Pulse oximetry measurement information, as well as instrument status data is displayed to a user on a handheld LCD screen **210** (FIG. **2**A). User input is handled through control keys **220**–**260** (FIG. **2**A) on a front panel. User input and displays are controlled by the handheld **101**. A sensor cable **10** connects into a swivel connector **20** on the handheld **100**. The handheld **101** is battery powered and can be used either as a transport monitor or as a handheld pulse oximeter for spot checks. A handheld release button **30** is pressed to pull the handheld **101** out of a docking station **103** (FIG. **1**B).

As shown in FIG. **1**B, the handheld **101** snaps into the docking station **103** to provide the standalone pulse oximeter **105**. The docking station **103** connects to AC power for standalone operation or handheld battery charging. In one embodiment, a docking station battery is also available. The standalone pulse oximeter **105** features an analog output/nurse call and a serial output that interfaces to, for example, a printer or computer.

As shown in FIG. **1**C, utilizing an interface cable **107**, the standalone **105** also interfaces to the sensor port of an SpO_2 module of a validated multiparameter patient monitor or other pulse oximeter monitor so as to upgrade conventional pulse oximetry to advanced pulse oximetry. The interface cable **107** attaches to the back of the docking station **105**.

A handheld pulse oximeter, docking station, standalone pulse oximeter and interface cable are described in U.S. patent application Ser. No. 09/516,110 filed Mar. 1, 2000 entitled "Universal/Upgrading Pulse Oximeter," assigned to the assignee of the present invention and incorporated by reference herein. Pulse oximeters having handheld, docking stations and standalone features include those commercially available from, for example, Masimo Corporation of Irvine, Calif., under the Radical™ brand. An associated publication entitled "Radical, Signal Extraction Pulse Oximeter, Operator's Manual," ©2001 Masimo Corporation is incorporated by reference herein. Interface cables are also available from, for example, Masimo Corporation under the SatShare™ brand.

Handheld Pulse Oximeter

FIGS. **2**A–C generally illustrate a pulse oximeter user interface. FIG. **2**A illustrates a handheld user interface having the display **210**, the fixed function keys **220**–**240**, programmable function keys ("soft keys") **260**, associated soft key icons **270** and a loudspeaker **280**. The loudspeaker **280** provides an audio indication of alarms, which are described with respect to FIGS. **11**A–B, below. The display **210** is described with respect to FIGS. **4**–**6**, below. The four soft keys **260** are pressed to select a corresponding one of the soft key icons **270**. The soft key icons **270** indicate the software menu items that can be selected through the soft keys **260**. Pressing a soft key **260** next to an icon **270** selects the option. The soft keys **260** and soft key icons **270** are described with respect to FIGS. **8**A–B, below.

As shown in FIG. **2**A, the fixed function keys **220**–**240** include a power/standby button **220**, an alarm silence button **230** and a backlight/contrast button **240**. The power/standby button **220** is pressed to turn the instrument on, and it is held down for more than 2 seconds and then released to turn the instrument off.

The alarm silence button **230** is pressed to temporarily silence patient alarms. Also, the alarm silence button **230** is pressed when SENSOR OFF or NO SENSOR messages are flashing, such as when the sensor is removed from the patient, to acknowledge the end of monitoring. In these states, all further alarms are suspended until the pulse oximeter starts measuring oxygen saturation (i.e. SpO_2) and pulse rate again. System fault alarms can be silenced by pressing the power/standby button **220** or the alarm silence button **230**.

The backlight/contrast button **240** is pressed to change the illumination level of the backlight. With the AC line power connected, four levels of illumination are available in addition to a no illumination level. In the handheld mode, three levels of illumination are available in addition to a no illumination level. The lowest illumination is used for the most efficient battery usage. The backlight/contrast button **240** is also used to change the contrast of the LCD display by pressing and holding it for longer than two seconds to begin the contrast change and releasing it at the desired contrast setting.

Standalone Pulse Oximeter

FIG. **2**B illustrates a standalone user interface having LED indicators **290** in addition to some or all of the interface features of the handheld, described above. When the handheld is placed into the docking station, the handheld can become a full-featured standalone pulse oximeter. The standalone acts as a battery charger for the handheld and has AC

power connection capabilities. The standalone can also interface to serial devices, nurse call or analog output devices, and multiparameter patient monitors through an interface cable.

FIG. **2**C illustrates the standalone LED indicators **290** including a docking station battery charging indicator **292**, a handheld battery charging indicator **294**, a visual alarm indicator **295**, an AC power indicator **297** and a docking indicator **299**. The docking station battery charging indicator **292** is illuminated when the docking station battery is charging. The handheld battery charging indicator **294** also is illuminated when the handheld battery is charging. Both charging indicators **292**, **294** blink just prior to charging. Neither charging indicator **294** illuminates when a battery is fully charged or when a battery is not present. The visual alarm indicator **295** is illuminated when an alarm condition is active and the alarm status indicator is shown. The AC power indicator **297** is illuminated when the docking station is plugged into AC line power. The docking indicator **299** is illuminated when the handheld is turned on and is properly interfaced to a docking station. When the standalone is turned on at start up, all indicator LEDs initially turn on and off.

User Interface Details

FIG. **3** provides a hierarchical overview **300** of the content of the user display **210** (FIG. **2**A) having display views **310**, display view soft key icons **320**, main menu and trend view **330**, submenus **340**, trend soft key icons **350** and trend-related screens **360**. There are three display views **310** including a pleth only view **400**, described with respect to FIG. **4**, a pleth and signal quality view **500**, described with respect to FIGS. **5**A–C, and a numeric view, described with respect to FIG. **6**.

As shown in FIG. **3**, there are two pages of soft key icons **320** that appear in the display views **310**. A first page of icons **801** includes a main menu icon **814** (FIG. **8**A) that, when selected, provides a main menu **900**. The main menu **900** includes soft key icons **820** (FIG. **8**A) that allow selection of the submenus **340**. A second page of icons **802** include a trend icon **864** (FIG. **8**B) that, when selected, provides a trend view **1000**. The trend view **1000** includes three pages of trend soft key icons **350**. One of the trend soft key icon pages **350** provides for the selection of the trend-related screens **360**. The display view icons **320**, main menu icons **820** (FIG. **8**A), and trend icons **350** are described with respect to FIGS. **8**A–B, below. The main menu **900** is described with respect to FIGS. **9**A–B, below, and the trend view **1000** is described with respect to FIG. **10**, below. The submenus **340** are described with respect to FIGS. **11**–**17**, below. The general submenu **1300** provides for the selection of a home mode and associated password screen **1800**, described with respect to FIG. **13** and FIG. **18**, below.

The content of the user display **210** (FIG. **2**A) can appear as a horizontal format or a vertical format. The content of the user display **210** (FIG. **2**A) can rotate between display formats as the handheld **101** (FIG. **1**A) or standalone **105** (FIG. **1**B) are physically moved to corresponding horizontal or vertical positions. Alternatively, the display content can rotate between horizontal and vertical formats by selection of a rotate soft key icon **868** (FIG. **8**B), described below. Horizontal and vertical format pairs are illustrated in FIGS. **5**A–B, **9**A–B, and **11**A–B. A rotatable format display is described in U.S. patent application Ser. No. 09/516,110, referenced above.

Display Views

Pleth View

FIG. **4** illustrates a pleth only view **400** having an oxygen saturation **412**, a pulse rate **414**, a perfusion index **418** and a pulse waveform **422**. The oxygen saturation **412** displays a functional arterial hemoglobin oxygen saturation measurement in units of percentage SpO_2. When a sensor is not connected to a patient and during pulse search, the display will show dashed lines. The oxygen saturation **412** is calculated and the display is updated at a frequency of once per second. The pulse rate **414** displays a patient's pulse rate in beats per minute. The pulse rate **414** is calculated and the display is updated at a frequency of once per second.

The pulse waveform **422** displays the acquired plethysmograph ("pleth"). The pulse waveform **422** is scaled with signal strength, as described in detail with respect to FIGS. **7**A–D, below. The pulse waveform **422** is updated at a frequency of 31.25 times per second. The perfusion index **418** displays the percentage of pulsatile signal to non-pulsatile signal.

As shown in FIG. **4**, the pleth view **400** also has saturation limits **432**, pulse rate limits **434** and an alarm status indicator **436**. The saturation limits **432** display the upper and lower saturation alarm limits. The saturation limits **432** are displayed next to the oxygen saturation **412**. The pulse rate limits **434** display the upper and lower pulse rate alarm limits. The pulse rate limits **434** are displayed next to the pulse rate **414**. When a measured value reaches or exceeds an alarm limit **432**, **434** the associated number display **412**, **414** and the corresponding violated limit **432**, **434** flash.

The alarm status indicator **436** is a bell symbol that can be shown with or without a slash. It flashes when an alarm condition is present. When the alarm is silenced using the alarm silence button **230** (FIG. **2**A), an alarm status indicator **436** with a slash and a timer is shown to indicate that the alarm is temporarily silenced. When the alarm is silenced through an "all mute" menu selection, which is permanent until power is cycled or deselected using menu, an alarm status indicator **436** with a slash is shown to indicate that alarm has been silenced.

Also shown in FIG. **4**, the pleth view **400** has status messages **442**–**448** and indicators **460**–**480**. The status messages include an advanced signal processing message ("Masimo SET") **442** when such processing is active, a fast signal processing message ("FastSat") **444** when operating in that mode, and a maximum sensitivity message ("Max") **448** when operating in that mode. The advance signal processing can include advanced pulse oximetry such as that commercially available from Masimo Corporation of Irvine, Calif. under the Masimo SET® brand. Fast signal processing is described in U.S. patent application Ser. No. 09/586,845 entitled "Variable Mode Averager," assigned to the assignee of the present invention and incorporated by reference herein.

The indicators include battery status indicators **460**, time and date indicators **470** and an output mode indicator **480**. Battery status indicators **460** show the capacity of the handheld and optional docking station batteries. An indicator **460** flashes when less than 15 minutes of battery life is left and the battery needs to be recharged. The docking station battery status indicator is not shown when the optional docking station battery is not present. The time and date indicators **470** display the current time and date. The date and time are displayed in dd/mm/yyyy or mm/dd/yyyy format. The date and time display format is selected in the clock menu **1400** (FIG. **14**). The output mode indicator **480** displays the output mode selected by the user. The output mode indicator **480** also displays the type of interface cable. In are embodiment, the output mode indicator **480** is only displayed when the instrument actively outputs data other than ASCII text or interfaces with a monitor through the interface cable.

Further shown in FIG. **4**, the pleth view **400** has system messages generated by the instrument that are displayed in a system message area **450**. Each message and its meaning are described immediately below. An "AMBIENT LIGHT" message indicates that too much light is on the patient (sensor). A "DEFECTIVE SENSOR" message indicates that the oximeter cannot identify the connected sensor or the sensor has failed, which, for example, may be caused by a broken sensor cable wire, inoperative LEDs, an unauthorized sensor, or a faulty detector. An "INTERFERENCE" message indicates that an outside signal or energy is preventing a reading. An "INVALID SENSOR" message indicates the oximeter cannot identify the connected sensor, which again can be due to a broken sensor cable wire, inoperative LEDs, an unauthorized sensor, or a faulty detector. A "LOW BATTERY" message indicates that the battery charge is low, signaling that the handheld be placed into the docking station to be powered with AC line power or that the battery be replaced. A "LOW PERFUSION" message indicates that the signal is too small. A "LOW SIGNAL IQ" message indicates a low signal quality, and is discussed further with respect to FIGS. **5**A–C, below. A "NO SENSOR" message indicates that a sensor is not fully inserted into the connector, which may be due to an incorrect sensor, or a defective sensor or cable, or that the sensor is inserted upside down. A "PULSE SEARCH" message indicates that the instrument is searching for patient's pulse. A "SENSOR OFF" message indicates that a sensor is off the patient and should be reattached. A "SERVICE REQUIRED" message indicates an internal failure and that the instrument requires service. The "SERVICE REQUIRED" message fills the entire display.

As shown in FIG. **4**, the pleth view **400** has soft key icons **270** as described with respect to FIG. **2**A, above. In the display views **400–600** (FIG. **3**), including the pleth view **400**, the soft key icons **270** can be page **1** display view icons **810** (FIG. **8**A) or page **2** display view icons **860** (FIG. **8**B), described below.

Pleth And Signal Quality View

FIGS. **5**A–B illustrate a pleth and signal quality view **500**, in horizontal and vertical format, respectively, having the features of the pleth only view **400** (FIG. **4**) in addition to a signal quality waveform **510**. The signal quality waveform **510** provides a visual indicator of the plethysmogram signal quality. In particular, the signal quality waveform **510** displays the acquired signal quality and the timing of a patient's pulse by a series of vertical lines **512**. With motion, the plethysmographic waveform is often distorted and may be obscured by one or more artifacts. The vertical lines **512** coincide with peaks of an arterial pulsation. Even with a plethysmographic waveform obscured by artifacts, the instrument locates the arterial pulsation. A pulse tone generated by the loudspeaker **280** (FIG. **2**), when enabled, coincides with the vertical lines **512**. The height of a particular vertical line of the signal quality waveform **510** indicates the quality of the measured signal. A generally large vertical line indicates that the SpO_2 measurement is based on a good quality signal. A generally small vertical line indicates that the SpO_2 measurement is based on data with low signal quality. When the signal quality is very low the accuracy of the SpO_2 measurement may be compromised and the "LOW SIGNAL IQ" system message **450** (FIG. **4**) is displayed, as described above. The signal quality waveform **510** is updated at a frequency of 31.25 times per second. Signal quality may also be shown as a single, pulsating bar **610** (FIG. **6**), as described with respect to the numeric view **600** (FIG. **6**), below. Signal quality is described in U.S. patent application Ser. No. 09/858,114 entitled "Pulse Oximetry Data Confidence Indicator," assigned to the assignee of the present invention and incorporated by reference herein.

Low signal quality may be due to various factors, such as improper sensor application, misalignment of the sensor's emitter and detector resulting in smaller signals, extreme changes in the patient's physiology and blood flow at the monitoring site, such as an inflated blood pressure cuff, a squeezing motion, sampling of an arterial blood specimen from the hand containing the pulse oximetry sensor, severe hypotension, peripheral vasoconstriction in response to hypothermia, medications, or a spell of Raynaud's syndrome. With neonates or infants, the peripheral blood flow to the sensor site may occur as the result of lifting or crossing of their legs, such as during a diaper change.

Numeric View

FIG. **6** illustrates a numeric view **600** having the features of the pleth view **400** (FIG. **4**) without the pulse waveform **422** (FIG. **4**). In particular, the numeric view prominently displays oxygen saturation **412** and pulse rate **414**. Further, the numeric view **600** features a signal quality bar **610** having a pulsating height that is responsive to the patient's arterial pulse and to signal quality. Signal quality is described with respect to FIGS. **5**A–B, above. Specifically, the bar height pulses coincide with peaks of an arterial pulsation and the bar height indicates signal quality, with a generally small bar height corresponding to low signal quality and a generally large bar height corresponding to high signal quality.

Stability of the oxygen saturation **412** readings may be a good indicator of signal validity. Although stability is a relative term, experience provides a good feeling for changes that are artifactual or physiological and the speed, timing, and behavior of each. The stability of the oxygen saturation **412** readings over time is affected by the averaging mode being used. The longer the averaging time, the more stable the readings tend to become. This is due to a dampened response as the signal is averaged over a longer period of time than during shorter averaging times. However, longer averaging times delay the response of the oximeter and reduce the measured variations of SpO_2 and pulse rate (PR). Inaccurate measurements may be caused by significant levels of dysfunctional hemoglobin (e.g., carboxyhemoglobin or methemoglobin), intravascular dyes such as indocyanine green or methylene blue, venous pulsations at the frequency of the patient's arterial pulse and very low hemoglobin levels.

The displayed pulse rate **414** may differ slightly from the heart rate displayed on ECG monitors due to differences in averaging times. There may also be a discrepancy between cardiac electrical activity and peripheral arterial pulsation. Significant differences may indicate a problem with the signal quality due to physiological changes in the patient or one of the instruments or application of the sensor or patient cable. The pulsations from intra-aortic balloon support can be additive to the pulse rate displayed on the pulse oximeter.

Pleth Auto-Scaling And Auto-Clipping

FIGS. **7**A–D illustrate auto-scaling and auto-clipping characteristics for the pulse waveform **422** (FIG. **4**) available on the pleth view **400** (FIG. **4**) or pleth and signal quality view **500** (FIGS. **5**A–C). The measured signal strength can vary quite widely. However, in a preferred embodiment, the signal strength can vary from 0% to 100%. In a more preferred embodiment, the signal strength can vary from 02% to 20%. The challenge is to display a measured waveform having three orders of magnitude dynamic range

in a meaningful way. FIG. **7**A illustrates an auto-scale/auto-clip graph **701** having a display target axis **710** in units of percentage of full-scale and a signal strength axis **720** in units of percentage of DC. Plotted on the graph **701** is a scaling/clipping curve **730**, which illustrates the display characteristics for the pulse waveform **422** (FIG. **4**) at various measured signal levels. FIG. **7**B illustrates an expanded graph **702** corresponding to FIG. **7**A for values along the signal strength axis **720** in a range from about 0 to 0.2%. FIGS. **7**A–B illustrate one auto-scaling and auto-clipping embodiment, where the measured pulse waveform is scaled to about a 90% full-scale value for all signal strength values above about 0.02% and clipped to about 0 for all signal strength values below about 0.02%.

FIG. **7**C illustrates an auto-scale/auto-clip graph **703** similar to **701** (FIG. **7**A). Plotted on the graph **703** is a scaling/clipping curve **750**, which illustrates the display characteristics for the pulse waveform **422** (FIG. **4**) at various measured signal levels. FIG. **7**D illustrates an expanded graph **704** corresponding to FIG. **7**C for values along the signal strength axis **720** in a range from about 0 to 0.5%. FIGS. **7**C–D illustrate another auto-scaling and auto-clipping embodiment where the measured pulse waveform is scaled to between about 15% and 90% full-scale in a piecewise linear fashion for signal strength values above about 0.02% and clipped to about 0 for all signal strength values below about 0.02%. In this manner, the displayed pulse waveform **422** (FIG. **4**) advantageously conveys to the user meaningful information about the measured signal strength. Specifically, for signal strength in the range of about 10%–20%, the pulse waveform **422** (FIG. **4**) is scaled to about 90% full-scale. For signal strength in the range of about 2% to 10%, the pulse waveform **422** (FIG. **4**) is scaled linearly to a corresponding range of about 60% to 90% full-scale. For signal strength in the range of about 0.5% to 2%, the pulse waveform **422** (FIG. **4**) is scaled linearly to a corresponding range of about 15% to 60% full-scale. For signal strength in the range of about 0.02% to 0.5%, the pulse waveform **422** (FIG. **4**) is scaled to about 15% full-scale. For signal strength in the range of about 0 to 0.02%, the pulse waveform **422** (FIG. **4**) is clipped to about 0.

Soft Keys

FIGS. **8**A–B are hierarchical charts of soft key icons corresponding to the soft key buttons **260** (FIG. **2**A). A soft key icon is selected by pressing and releasing the soft key button to the right of the icon (horizontal display) or underneath the icon (vertical display). Four icons are shown on the right side or bottom of the display. FIG. **8**A illustrates a first set of soft key icons **801**, including the first page of display view icons **810**, menu icons **820**, category icons **830** and parameter icons **840**. FIG. **8**B illustrates a second set of soft key icons **802**, including the second page of display view icons **860** and trend-related icons **870**–**890**. The display view icons **810** (FIG. **8**A), **860** (FIG. **8**B) are those icons initially shown on the three views **400** (FIG. **4**), **500** (FIGS. **5**A–B), **600** (FIG. **6**), described above. The menu icons **820** (FIG. **8**A) are those icons shown on the main menu **900** (FIGS. **9**A–B). The category **830** and parameter **840** icons are those shown on the submenus **1100**–**1700** (FIGS. **11**–**17**). The trend-related icons **870**–**890** (FIG. **8**B) are those icons shown on the trend view **1000** (FIG. **10**) and on the trend-related menus and screens **1900**–**2100** (FIGS. **19**–**21**).

As shown in FIG. **8**A, the first page of display view icons **810** include next page **812**, menu access **814**, increase loudness **816** and decrease loudness **818**. Next page **812** is selected to access the second page of display view icons **860** (FIG. **8**B). Menu access **814** is selected to enter the main menu **900** (FIGS. **9**A–B). Increase loudness **816** is selected to increase the volume of the pulse beep. In one embodiment, there are seven levels of volume available. Decrease loudness **818** is selected to decrease the volume of the pulse beep. The lowest volume level will silence the pulse beep and the decrease loudness **818** icon will appear with a slash through it.

As shown in FIG. **8**B, the second page of display view icons **860** include next page **862**, trend display **864**, sensitivity **866** and rotate display **868**. Next page **862** is selected to return to the first page of display view icons **810** (FIG. **8**A). Trend display **864** is selected to show the trend view **1000** (FIG. **10**). Sensitivity **866** is selected to toggle between normal and maximum sensitivity modes. Normal sensitivity is used for normal patient monitoring purposes. Maximum sensitivity is used for improved sensitivity performance on patients with extremely low perfusion. With the maximum sensitivity setting, the SENSOR OFF detection performance may be compromised. In one embodiment, the instrument automatically retains a sensitivity setting after a power cycle, and in another embodiment, the instrument does not retain a sensitivity setting after a power cycle. Rotate display **868** is selected to reconfigure the display contents in a vertical or horizontal format. The display contents rotate clockwise in 90 degree increments, accordingly.

Main Menu

FIGS. **9**A–B illustrate horizontal and vertical formats, respectively, of a main menu **900**. When the main menu **900** is accessed, the plethysmograph and signal quality waveform displays are replaced with main menu categories **910**. The display view soft key icons **810** (FIG. **8**A), **860** (FIG. **8**B) are also replaced by the main menu soft key icons **820** (FIG. **8**A). When the main menu **900** is accessed the instrument remains functional and the saturation and pulse rate numbers will continue to be displayed.

As shown in FIG. **8**A, the main menu **900** (FIGS. **9**A–B) uses the four main menu icons **820**, including exit **822**, select category **824**, previous **826** and next **828**. Exit **822** is selected to exit the main menu **900** (FIGS. **9**A–B) and return to the original display view. Select category **824** is selected to choose a highlighted menu category **910** (FIGS. **9**A–B) and display the corresponding submenu **1100**–**1700** (FIGS. **11**–**17**). Previous **826** is selected to scroll through the menu categories **910** (FIGS. **9**A–B), highlighting categories without selecting them. Next **828** is selected to scroll through the menu categories **910** (FIGS. **9**A–B), in a direction opposite from previous **826**, also highlighting categories without selecting them. Once a menu category **910** (FIGS. **9**A–B) is highlighted, the chosen submenu **1100**–**1700** (FIGS. **11**–**17**) is displayed with a select category **824** selection.

Also shown in FIG. **8**A, a submenu **1100**–**1700** (FIGS. **11**–**17**) is displayed with a set of category icons **830**, including exit **832**, edit parameter **834**, previous **836** and next **838**. Exit **832** is selected to exit the category submenu **1100**–**1700** (FIGS. **11**–**17**) and return to the main menu **900** (FIGS. **9**A–B). Edit parameter **834** is selected to choose a highlighted parameter in a submenu for editing. Previous **836** and next **838** function in a similar manner as described above to highlight parameters without selecting them. Once a parameter is highlighted, the parameter is edited by selecting edit parameter **834**.

Further shown in FIG. **8**A, once a parameter has been selected for editing, a set of parameter icons **840** are displayed, including exit **842**, accept **844**, previous **846** and next **848**. Exit **842** is selected to exit a parameter without making any new selections permanent. Accept **844** is

selected to save any changes. Previous **846** is selected to increase or toggle a parameter settings. Next **848** is selected to decrease or toggle a parameter settings. Submenus and associated parameters are described in more detail with respect to FIGS. **11–17**, below.

Trend View

FIG. **10** illustrates a trend view **1000** having a first line of information **1010**, a second line of information **1020**, an oxygen saturation trend graph **1030**, a low signal quality indicator **1040**, and a pulse rate trend graph **1050**. The first line **1010** on the trend view **1000** shows the time scale of the trend graph, followed by the starting date, starting time and end time of the data set that is displayed on the screen. The second line **1020** of the trend view **1000** shows the minimum, average, and maximum SpO_2 and pulse rate measurements contained in the displayed data set (excluding zero measurements). The oxygen saturation trend graph **1030** shows the SpO_2 measurements displayed versus time. The pulse rate trend graph **1050** shows the pulse rate measurements displayed versus time. A dark line **1032, 1034** on the trend graphs **1030, 1050** indicates averaged data, while grayed-out data points show minimum and maximum values. The low signal quality indicator **1040** appears as a grayed-out box, line or other designation located on the bottom axis or other portion of the oxygen saturation trend graph **1030** and indicates a period of time for which the "LOW SIGNAL IQ" message was active. During this time, the signal quality was very low and the accuracy of the measurement may have been compromised. The vertical scale of the oxygen saturation **1030** and pulse rate **1050** graphs can be set in the trend setup screen **1900** (FIG. **19**).

Once the trend display icon **864** (FIG. **8**B) is selected, the trend data is shown on the trend view **1000**. The instrument stores one data set of oxygen saturation, pulse rate and system messages in a dedicated memory area. Depending on the trend period, a setting for how often the data is stored in the trend memory, the instrument can store between 72 hours and 30 days worth of trend data. The instrument also employs data compression. The actual amount of trend data that is stored is dependent on the type of data that is collected. The instrument only stores data in the trend memory while the instrument is turned on, and the trend data remains in memory until the memory fills up or is cleared by the user. Changing the date and time of the system clock or changing the trend period will also clear the data in the trend memory. The trend capacity for a trend period setting of 2 seconds is a minimum of 72 hours (3 days). For a trend period setting of 10 seconds, the trend memory capacity is typically 720 hours (30 days).

By default, the trend view **1000** automatically refreshes at a rate of once every 10 seconds, to show the latest measured SpO_2 and pulse rate data. This feature is only available while the trend view is 2 hours or less and the latest measured data is shown. If the user scrolls through the data set to display previously recorded trend data or if the trend scale is greater than 2 hours, the trend view will time out after 1 minute of inactivity (i.e. the user does not press any of the soft key buttons) and the previous display view will be shown.

As shown in FIG. **8**B, in the trend view there are a total of 12 soft key icon selections **870–890** on 3 pages. The first page has next menu **872**, exit **874**, scroll left **876** and scroll right **878** icons. Next menu **872** is selected to access the next page of menu selections. Exit **874** is selected to return to the previous display view. Scroll left **876** is selected to scroll through the data set in the backward time direction. Scroll right **878** is selected to scroll through the data set in the forward time direction. The display scrolls by ½ the selected time scale. For example, if a 2 hr display view is selected, then selecting scroll left **876** or scroll right **878** will scroll the displayed data by 1 hr to the left or right, respectively.

Also shown in FIG. **8**B, the second page has next menu **882**, zoom **884**, zoom from left **886**, and zoom from right **888** icons. Next menu **882** is selected to access the next page of icons. Zoom **884** is selected to change the time scale of the trend view. The available time scales are 24 hrs, 12 hrs, 8 hrs, 4 hrs, 2 hrs, 1 hr, 30 minutes, 10 minutes, 1 minute and 20 seconds. Zoom **884** uses the last recorded data point as the zoom reference point. In other words, the last recorded data point is always shown as the right-most data point on the display. Zoom from left **886** is selected to zoom into the data set while keeping the data point that is shown on the right side of the trend graph as the zoom reference point. Zoom from right **888** is selected to zoom into the data set while keeping the data point that is shown on the left side of the trend graph as the zoom reference point.

Further shown in FIG. **8**B, the third page has next menu **882**, trend setup **884**, histogram **896** and clear trend data **898** icons. Next menu **882** is selected to return to the first page of icons. Trend setup **884** is selected to enter the trend setup screen **1900** (FIG. **19**). Histogram **896** is selected to display the selected data set (the data set shown in the trend view) in histogram format **2000** (FIG. **20**). Clear trend data **898** is selected to clear the data stored in the trend memory, which is verified via a confirmation screen **2100** (FIG. **21**).

FIGS. **11**A–B illustrate an alarms menu **1100** in horizontal and vertical formats, respectively, having a high SpO_2 alarm limit **1110**, a low SpO_2 alarm limit **1120**, a high pulse rate alarm limit **1130**, and a low pulse rate alarm limit **1140**. Alarm limit settings are typically checked each time the pulse oximeter is used to ensure that they are appropriate for the patient being monitored. An audible alarm and a flashing alarm status indicator **432** (FIG. **4**) will occur when an alarm limit is met or exceeded.

The SpO_2 high alarm limit **1110** can be set anywhere between 2% and 100%, with a 1% step size. In the "—" (off) setting, the alarm can be turned off completely. The SpO_2 low alarm limit **1120** can be set anywhere between 1% and 100%, with a 1% step size. The pulse rate high alarm limit **1130** can be set anywhere between 30 BPM and 240 BPM, with a 5 BPM step size. The pulse rate low alarm limit **1140** can be set anywhere between 25 BPM and 235 BPM, with a 5 BPM step size. The low alarm limits **1120, 1140** always have to be set below the corresponding high alarm limits **1110, 1130**. When a high alarm limit **1110, 1130** is set below the corresponding low alarm limit **1120, 1140**, the low alarm limit **1120, 1140** will automatically adjust to the next setting below the newly entered high alarm limit **1110, 1130**.

As shown in FIGS. **11**A–B, the alarms menu **1100** also has alarm limit type **1150**, silence **1160**, volume **1170** and delay **1180** settings. The instrument stores three alarm limit types **1150** including adult, neo and custom limits. Adult and neo limits are preset and cannot be changed by the user. Table 1 outlines the default values of the preset and custom alarm limit types **1150**.

TABLE 1

TYPES	SpO_2 HIGH	SpO_2 LOW	PR HIGH	PR LOW
Adult	Off	90%	140 BPM	50 BPM
Neo	100%	90%	180 BPM	100 BPM
Custom	Off	90%	140 BPM	50 BPM

The custom limits are set to the values listed in the table at the factory. Once the values are changed, the new values are retained after a power cycle.

The alarm menu **1100** allows the user to set an alarm silence duration **1160**. An alarm is silenced by pressing the alarm silence button **230** (FIG. **2**A) on the front panel. The alarm silence duration **1160** can be virtually any amount of time. However, in a preferred embodiment, the duration **1160** is set as 30, 60, 90 and 120 seconds. As an indicator that the alarm system is silenced, the alarm status indicator **436** (FIG. **4**) is shown as a bell with a slash through it. A timer is shown next to the bell indicating the remaining alarm silence duration. The alarm silence duration **1160** is reset to 120 seconds upon a power cycle, except for when the instrument is set to operate in the home mode. In an all mute mode, all patient alarm conditions are silenced. Only system alarms will be indicated by an audible alarm. As an indicator that the system is set to all mute, the alarm status indicator **436** (FIG. **4**) is shown as a flashing bell with a slash through it. In an all mute with audible reminder mode, all patient alarm conditions are silenced. Only system alarms will be indicated by an audible alarm. As a reminder, a single audible alarm will occur every three minutes.

Also shown in FIGS. **11**A–B, the alarm menu **1100** allows the user to set the alarm volume **1170**. According to one embodiment, four levels are available, with level **1** being the softest and level **4** being the loudest. The instrument retains the alarm volume **1170** setting upon a power cycle. For home use, the alarm level to typically set to level 4. If an alarm condition occurs while the alarm silence period is set to all mute, the only alarm indications will be visual displays and symbols related to the alarm condition. No alarm tone will sound.

FIG. **12** illustrates the display menu **1200** having display view **1210**, contrast **1220** and language **1230** items. The display view item **1210** allows selection of one of the three display views including pleth **400** (FIG. **4**), pleth and signal quality **500** (FIGS. **5**A–B) and numeric **600** (FIG. **6**), described above. The contrast item **1220** allows the user to set the display contrast. According to one embodiment, contrast ranges from 1 to 64. The contrast can also be set by pressing and holding the backlight/contrast key **240** (FIG. **2**A) on the front panel. The language item **1230** allows the user to select the display language.

FIG. **13** illustrates a general menu **1300** having averaging time **1310**, FastSat **1320**, home use **1330**, interface alarms **1340**, SatShare numbers **1350** and power save **1360** items. Averaging time **1310** is the signal averaging time of the instrument, which can be set to include 2, 4, 8, 10, 12, 14 and 16 seconds. FastSat **1320**, when set to "yes," activates a fast signal processing algorithm, such as described in U.S. patent application Ser. No. 09/586,845 referenced above. In the 2 and 4 seconds averaging mode, the fast signal processing algorithm is automatically enabled. With fast signal processing, the averaging time is dependent on the input signal. For the 2 and 4 second settings, the averaging times may range from 2–4 and 4–6 seconds, respectively.

As shown in FIG. **13**, home use **1330**, when set to "yes," places the instrument in the home mode, where it remains until the "no" setting is selected. A password is required to activate or deactive this mode. Home use operation is described further with respect to FIG. **18**, below. Interface alarms **1340** allows audible alarms to be enabled or disabled. SatShare numbers **1350** is set to "yes" to display saturation and pulse rate measurements during upgrade operation, as described with respect to FIG. **1**C, above.

Also shown in FIG. **13**, power save **1360** can be set to "yes" or "no," to adjust battery-operating time of the instrument while powered by the handheld battery or optional docking station battery. Selecting "yes" disables docking station functions such as the interface cable, serial and analog outputs. Selecting "no" activates these docking station functions while operating on battery power. While operating in the power save mode, a power cycle of the instrument may be required to activate the docking station again after it has been disabled.

FIG. **14** illustrates a clock menu **1400** having time **1410**, time format **1420**, date **1430** and date format **1440** items. The time item **1410** sets the hour and minutes. The time format item **1420** sets the time display in 12 hour (default) and 24 hour format. The date item **1430** sets the day, month and year. The date format item **1440** sets the date display in mm/dd/yyyy (default) and dd/mm/yyyy format.

FIG. **15** illustrates the about screen **1500**. The about screen **1500** simply displays the copyright and software versions of the handheld **101** (FIG. **1**A) and the docking station **103** (FIG. **1**B).

FIG. **16** illustrates the output menu **1600** having serial **1610**, analog **1620** and nurse call **1630** output modes. The output menu selections are available when the handheld **101** (FIG. **1**A) is interfaced to the docking station **103** (FIG. **1**B). The serial item **1610** allows a user to specify various serial output modes, which, according to one embodiment, are RS-232 based. In ASCII 1 mode, for example, ASCII text data is sent to the serial interface at one-second intervals. The ASCII text includes date and time stamp, SpO_2 pulse rate, PI, and alarm and exception values. All text is single line followed by a line feed character and a carriage return. In ASCII 2 mode, ASCII text data is sent to the serial interface following a query from the connecting computer.

The analog items **1620** specify the docking station analog outputs. In 0%–100% mode, the saturation measurement is scaled with 0% being equal to 0 volts and 100% equal to 1 volt. In 50%–100% mode, the saturation measurement is scaled with 50% being equal to 0 volts and 100% equal to 1 volt. In the 0V mode, a 0 volts calibration signal is mapped onto the analog outputs. This signal is used for calibration of recording devices, where 0 volts represent a saturation of 0% and a pulse rate of 0 bpm. In the 1V mode, a 1 volt calibration signal is mapped onto the analog outputs. This signal is also used for calibration of recording devices, where 1 volt represents a saturation of 100% and a pulse rate of 250 bpm. In pleth mode, the pulse waveform is scaled with 1 volt being equal to 100% full scale. In signal IQ mode, 1 volt is equal to maximum signal quality. The nurse call item **1630** can specify alarms and low signal quality as generating a nurse call.

FIG. **17** illustrates a service menu **1700** having handheld battery discharge **1710** and docking station (DS) battery discharge **1720** items. The service menu **1700** selections are only available when the handheld **101** (FIG. **1**A) is interfaced to the docking station **103** (FIG. **1**B). Each of these items **1710**, **1720**, when selected, causes the instrument to perform a deep discharge the respective handheld or docking station battery. The discharge cycle will take approximately 16 hours to complete for the handheld battery and approximately 30 hours to complete for the docking station battery. A message will appear in the service screen when the discharge cycle is complete. The batteries will be fully charged after completion of the cycle.

FIG. **18** illustrates a password entry display **1800**. A password is entered using the password soft key icons **1810** and pressing in a particular sequence the corresponding soft key buttons **260** (FIG. **2**A) to the right or bottom of the display. In a home mode, a password is required to access the menu system and the soft key buttons and icons. When the instrument is set to operate in the home mode, the default

values that the instrument reverts to after a power cycle are set according to a predetermined setting with the exception of the alarm silence setting, which is set to the pre-power down setting. The instrument can be placed into the home mode to protect unqualified users from changing the alarm settings and operation. Entering a password does not automatically reset the instrument to a normal operating mode. To return to a normal operating mode, the home use parameter **1330** (FIG. **13**) is set to "No" in the general menu **1300** (FIG. **13**).

FIG. **19** illustrates a trend setup menu **1900** having %SpO_2 max and min **1910**, BPM max and min **1920**, default view **1930**, trend action **1940** and trend period **1950** items. The trend setup menu **1900** allows the user to set the default trend settings and to clear the trend data or download the trend data to the serial port. The default settings are used to scale the trend graphs when the trend data icon **864** (FIG. **8**B) is selected. %SpO_2 max and min **1910** set the high and low scale, respectively, of the SpO_2 trend graph **1030** (FIG. **10**). BPM max and min **1920** set the high scale, respectively, of the pulse rate trend graph **1050** (FIG. **10**). Default view **1930** selects the default time scale of the trend view **1000** (FIG. **10**). This setting only selects the time scale of the trend view **1000** (FIG. **10**) when the trend data is initially displayed, (i.e. when the trend data is initially accessed). According to one embodiment, the selections include 24 hrs, 12 hrs, 8 hrs, 4 hrs, 2 hrs, 1 hr, 30 minutes, 10 minutes, 1 minute and 20 seconds.

As shown in FIG. **19**, trend action **1940** has serial dump, analog dump and print options. The serial dump option sends all the data that is stored in trend memory to the serial port and is used to communicate the stored data set to trend graphing software applications. The analog dump option sends all the data that is stored in the trend memory to the analog output and is used to print the trend information on an analog chart recorder. The print option prints the trend data that is shown in the trend view **1000** (FIG. **10**). The trend data is first printed in histogram format, followed by a table of data that shows the time and date stamp of a trend record and the SpO_2 and pulse rate measurement. Each trend record is printed on a single line, followed by a carriage return and line feed character.

Also shown in FIG. **19**, trend period **1950** determines how often a set of SpO_2 and pulse rate data points is stored in trend memory. A setting of 2, for example, sets the instrument to store one set of SpO_2 and pulse rate measurements every 2 seconds, resulting in a minimum trend capacity of 72 hours. A setting of 10, for example, sets the instrument to store one set of data points every 10 seconds, resulting in a typical trend storage capacity of 30 days. Because of data compression, the actual trend capacity is dependent on the type of data that is collected.

A pulse oximetry user interface has been disclosed in detail in connection with various embodiments. These embodiments are disclosed by way of examples only and are not to limit the scope of the claims that follow. One of ordinary skill in the art will appreciate from the disclosure herein any variations and modifications.

Additionally, all publications, patents, and patent applications mentioned in this specification are herein incorporated by reference to the same extent as if each individual publication, patent, or patent application was specifically and individually indicated to be incorporated by reference.

What is claimed is:

1. A pulse oximetry user interface comprising:

a display;

a plurality of views each configured to occupy said display, each of said views adapted to present data responsive to a physiological signal;

a plurality of icons configured to occupy a portion of said views and adapted to designate the content of said views;

a plurality of keys proximate to said display and corresponding to said icons so as to select said icons;

a scale associated with said pulse waveform;

a signal strength measure corresponding to said physiological signal; and

a relationship between said signal strength and said scale so that said pulse waveform conveys information regarding said signal strengths,

wherein one of said views presents a pulse waveform, another of said views presents a trend graph, and at least one of said icons can be selected so as to switch said display between said one view and another view.

2. The pulse oximetry user interface according to claim **1** wherein said relationship is a piecewise-linear auto-scaling function.

3. The pulse oximetry user interface according to claim **2** wherein

said pulse waveform is about 90% full scale for signal strengths in the range of about 10% to 20% DC;

said pulse waveform is in the range of about 60% to 90% full scale for signal strengths in the range of about 2% to 10% DC;

said pulse waveform is in the range of about 15% to 60% full scale for signal strengths in the range of about 0.5% to 2% DC; and

said pulse waveform is about 15% full scale for signal strengths in the range of about 0.02% to 0.5% DC.

4. A pulse oximetry user interface method comprising the steps of:

deriving a pulse waveform responsive to a physiological signal;

calculating a data trend responsive to said physiological signal;

providing said pulse waveform in a first display view;

presenting at least a portion of said data trend in a second display view;

selecting a first icon accessible from said first display view to switch to said second display view;

selecting a second icon accessible from said second display view to switch to said first display view;

determining a signal strength for said physiological signal; and

scaling said pulse waveform according to a piecewise linear relationship so as to be responsive to said signal strength.

5. A pulse oximetry user interface method comprising the steps of:

deriving a pulse waveform responsive to a physiological signal;

calculating a data trend responsive to said physiological signal;

providing said pulse waveform in a first display view;

presenting at least a portion of said data trend in a second display view;

selecting a first icon accessible from said first display view to switch to said second display view;

selecting a second icon accessible from said second display view to switch to said first display view;

determining a first portion of said data trend corresponding to a first time period;

determining a second portion of said data trend corresponding to a second time period, where said first time period and said second time periods are about equal; and

selecting said first portion or said second portion for said second display view based on a scroll icon provided in said second display view.

6. A pulse oximetry user interface method comprising the steps of:

deriving a pulse waveform responsive to a physiological signal;

calculating a data trend responsive to said physiological signal;

providing said pulse waveform in a first display view;

presenting at least a portion of said data trend in a second display view;

selecting a first icon accessible from said first display view to switch to said second display view;

selecting a second icon accessible from said second display view to switch to said first display view;

determining a first portion of said data trend corresponding to a first time period;

determining a second portion of said data trend corresponding to a second time period, where said first time period is an integral multiple larger than said second time periods; and

selecting said first portion or said second portion for said second display view based on a zoom icon provided in said second display view.

7. A pulse oximetry user interface comprising:

a view means for presenting to a user data responsive to a physiological signal;

a main menu means for choosing display related categories;

a category menu means for choosing display related parameters, said parameters determining the characteristic of said view means;

an icon means for designating said view means, accessing said menu means and altering said parameters;

a soft key means for selecting said icon means

a pulse waveform portion of said view means responsive to said physiological signal; and

an auto-scaling means applied to said pulse waveform portion for indicating the signal strength of said physiological signal.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

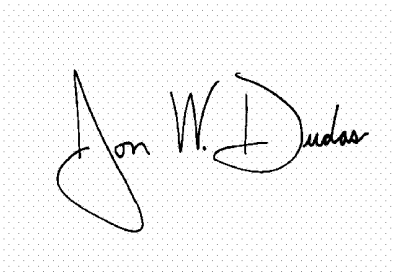
PATENT NO. : 6,658,276 B2
DATED : December 2, 2003
INVENTOR(S) : Massi E. Kiani et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,
Item [75], Inventors, change "**Massi E. Kianl**" to -- **Massi E. Kiani** --.

Signed and Sealed this

Twenty-seventh Day of December, 2005



JON W. DUDAS
Director of the United States Patent and Trademark Office

专利名称(译)	脉搏血氧仪用户界面		
公开(公告)号	US6658276	公开(公告)日	2003-12-02
申请号	US10/076860	申请日	2002-02-12
[标]申请(专利权)人(译)	KIANL MASSIê AL ALI AMMAR 卡罗瑟斯DON LEE MICHAEL PISHNEY JAMES WEBER WALTER中号		
申请(专利权)人(译)	kianl Massi E. AL-ALI AMMAR 卡罗瑟斯DON LEE MICHAEL PISHNEY JAMES WEBER WALTER M.		
当前申请(专利权)人(译)	摩根大通银行，NATIONAL ASSOCIATION		
[标]发明人	KIANL MASSI E AL ALI AMMAR CAROTHERS DON LEE MICHAEL PISHNEY JAMES WEBER WALTER M		
发明人	KIANL, MASSI E. AL-ALI, AMMAR CAROTHERS, DON LEE, MICHAEL PISHNEY, JAMES WEBER, WALTER M.		
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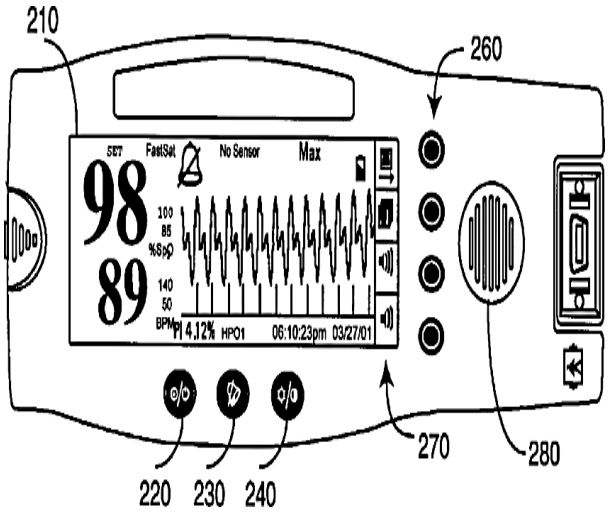
优先权	60/117097 1999-01-25 US 60/268207 2001-02-12 US 60/161565 1999-10-26 US		
其他公开文献	US20020161291A1		
外部链接	Espacenet USPTO		

摘要(译)

脉搏血氧测量用户界面具有显示器和多个视图，每个视图被配置为占据显示器。每个视图适于呈现响应于生理信号的数据。多个图标被配置为占据视图的一部分并适于指定视图的内容。此外，多个键靠近显示器并对应于图标以便选择图标。其中一个视图是提供脉冲波形的视图。另一个视图是呈现趋势图的趋势视图。可以选择至少一个图标，以便在体视图和趋势视图之间切换显示。


210
260
SET
FastSat
No Sensor
Max
98
100
85
%SpO
89
140
50
BPM
PI 4.12%
HPO1
06:10:23pm 03/27/01
270
280
220
230
240