US008190223B2

(12) **United States Patent**
Al-Ali et al.

(10) **Patent No.: US 8,190,223 B2**
(45) **Date of Patent: May 29, 2012**

(54) **NONINVASIVE MULTI-PARAMETER PATIENT MONITOR**

(75) Inventors: **Ammar Al-Ali**, Tustin, CA (US); **Joe Kiani**, Laguna Niguel, CA (US); **Mohamed Diab**, Mission Viejo, CA (US); **Greg Olsen**, Irvine, CA (US); **Roger Wu**, Irvine, CA (US); **Rick Fishel**, Orange, CA (US)

(73) Assignee: **Masimo Laboratories, Inc.**, 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 1661 days.

(21) Appl. No.: **11/367,033**

(22) Filed: **Mar. 1, 2006**

(65) **Prior Publication Data**

US 2006/0226992 A1 Oct. 12, 2006

Related U.S. Application Data

(60) Provisional application No. 60/657,596, filed on Mar. 1, 2005, provisional application No. 60/657,281, filed on Mar. 1, 2005, provisional application No. 60/657,268, filed on Mar. 1, 2005, provisional application No. 60/657,759, filed on Mar. 1, 2005.

(51) **Int. Cl.**
A61B 5/1455 (2006.01)

(52) **U.S. Cl.** **600/310**; 600/323; 600/324; 600/326

(58) **Field of Classification Search** 600/309–344
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,910,701	A		10/1975	Henderson et al.
3,998,550	A		12/1976	Konishi et al.
4,014,321	A	*	3/1977	March 600/319
4,157,708	A		6/1979	Imura
4,167,331	A		9/1979	Nielsen
4,266,554	A		5/1981	Hamaguri
4,267,844	A		5/1981	Yamanishi
4,446,871	A		5/1984	Imura
4,531,527	A		7/1985	Reinhold, Jr. et al.
4,586,513	A		5/1986	Hamaguri
4,621,643	A		11/1986	Newet al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP	41 92 23	3/1991
EP	0 569 670	2/1993
EP	0569670	11/1993

(Continued)

OTHER PUBLICATIONS

International Search Report for PCT/US2006/007516, mailed on Jan. 11, 2007, in 4 pages.

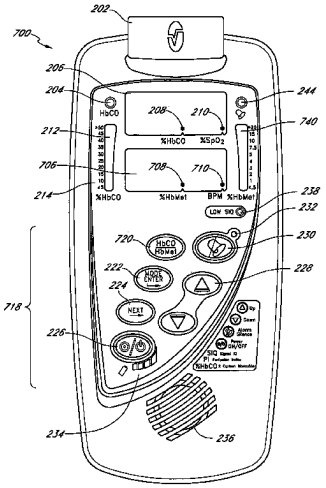
(Continued)

Primary Examiner — Eric Winakur
Assistant Examiner — Marjan Fardanesh
(74) *Attorney, Agent, or Firm* — Knobbe Martens Olson & Bear LLP

(57) **ABSTRACT**

Embodiments of the present disclosure include a handheld multi-parameter patient monitor capable of determining multiple physiological parameters from the output of a light sensitive detector capable of detecting light attenuated by body tissue. For example, in an embodiment, the monitor is capable of advantageously and accurately displaying one or more of pulse rate, plethysmograph data, perfusion quality, signal confidence, and values of blood constituents in body tissue, including for example, arterial carbon monoxide saturation ("HbCO"), methemoglobin saturation ("HbMet"), total hemoglobin ("Hbt"), arterial oxygen saturation ("SpO_2"), fractional arterial oxygen saturation ("$SpaO_2$"), or the like. In an embodiment, the monitor advantageously includes a plurality of display modes enabling more parameter data to be displayed than the available physical display real estate.

47 Claims, 18 Drawing Sheets



APPLE 1001

U.S. PATENT DOCUMENTS

4,653,498	A	3/1987	New, et al.
4,655,225	A	4/1987	Dahne et al.
4,685,464	A	8/1987	Goldberger et al.
4,694,833	A	9/1987	Hamaguri
4,700,708	A	10/1987	New et al.
4,714,341	A	12/1987	Hamaguri et al.
4,770,179	A	9/1988	New et al.
4,773,422	A	9/1988	Isaacson et al.
4,781,195	A	11/1988	Martin
4,800,885	A	1/1989	Johnson
4,805,623	A	2/1989	Jobsis
4,832,484	A	5/1989	Aoyagi et al.
4,846,183	A	7/1989	Martin
4,863,265	A	9/1989	Flower et al.
4,867,571	A	9/1989	Frick et al.
4,869,254	A	9/1989	Stone et al.
4,907,876	A	3/1990	Suzuki et al.
4,911,167	A	3/1990	Corenman et al.
4,934,372	A	6/1990	Corenman et al.
4,938,218	A	7/1990	Goodman et al.
4,942,877	A	7/1990	Sakai et al.
4,955,379	A	9/1990	Hall
4,960,126	A	10/1990	Conlon et al.
4,960,128	A	10/1990	Gordon et al.
4,964,010	A	10/1990	Miyasaka et al.
4,964,408	A	10/1990	Hink et al.
4,967,571	A	11/1990	Sporri
4,975,581	A	12/1990	Robinson et al.
4,986,665	A	1/1991	Yamanishi et al.
4,997,769	A	3/1991	Lundsgaard
5,025,791	A	6/1991	Niwa
RE33,643	E	7/1991	Isaacson et al.
5,028,787	A	7/1991	Rosenthal et al.
5,033,472	A	7/1991	Sato et al.
5,041,187	A	8/1991	Hink et al.
5,054,495	A	10/1991	Uemura et al.
5,058,588	A	10/1991	Kaestle et al.
5,069,213	A	12/1991	Polczynski
5,077,476	A	12/1991	Rosenthal
5,078,136	A	1/1992	Stone et al.
5,137,023	A	8/1992	Mendelson et al.
5,163,438	A	11/1992	Gordon et al.
5,189,609	A	2/1993	Tivig et al.
5,190,040	A	3/1993	Aoyagi
5,209,230	A	5/1993	Swedlow et al.
5,226,053	A	7/1993	Cho et al.
5,246,002	A	9/1993	Prosser
5,247,931	A	9/1993	Norwood
5,259,381	A	11/1993	Cheung et al.
5,267,562	A	12/1993	Ukawa et al.
5,267,563	A	12/1993	Swedlow et al.
5,278,627	A	1/1994	Aoyagi
5,297,548	A	3/1994	Pologe
5,313,940	A	5/1994	Fuse et al.
5,331,549	A	7/1994	Crawford, Jr.
5,335,659	A	8/1994	Pologe et al.
5,337,744	A	8/1994	Branigan
5,337,745	A	8/1994	Benaron
5,341,805	A	8/1994	Stavridi et al.
5,348,004	A	9/1994	Hollub
5,351,685	A	10/1994	Potratz
5,355,880	A	10/1994	Thomas et al.
5,355,882	A	10/1994	Ukawa et al.
5,361,758	A	11/1994	Hall et al.
5,368,224	A	11/1994	Richardson et al.
D353,195	S	12/1994	Savage et al.
D353,196	S	12/1994	Savage et al.
5,377,676	A	1/1995	Vari et al.
5,385,143	A	1/1995	Aoyagi
5,387,122	A	2/1995	Goldberger et al.
5,392,777	A	2/1995	Swedlow et al.
5,413,101	A	5/1995	Sugiura
D359,546	S	6/1995	Savage et al.
5,421,329	A	6/1995	Casciani et al.
5,427,093	A	6/1995	Ogawa et al.
5,429,128	A	7/1995	Cadell et al.
5,431,170	A	7/1995	Mathews
5,435,309	A	7/1995	Thomas et al.
D361,840	S	8/1995	Savage et al.
D362,063	S	9/1995	Savage et al.
5,452,717	A	9/1995	Branigan et al.
D363,120	S	10/1995	Savage et al.
5,456,252	A	10/1995	Vari et al.
RE35,122	E	12/1995	Corenman et al.
5,482,036	A	1/1996	Diab et al.
5,490,505	A	2/1996	Diab et al.
5,490,523	A	2/1996	Isaacson et al.
5,494,032	A	2/1996	Robinson et al.
5,494,043	A	2/1996	O'Sullivan et al.
5,503,148	A	4/1996	Pologe et al.
5,520,177	A	5/1996	Ogawa
5,533,507	A	7/1996	Potratz
5,533,511	A	7/1996	Kaspari et al.
5,551,423	A	9/1996	Sugiura
5,553,615	A	9/1996	Carim et al.
5,555,882	A	9/1996	Richardson et al.
5,561,275	A	10/1996	Savage et al.
5,562,002	A	10/1996	Lalin
5,575,284	A *	11/1996	Athan et al. 600/323
5,577,500	A	11/1996	Potratz
5,584,299	A	12/1996	Sakai et al.
5,588,427	A	12/1996	Tien
5,590,649	A	1/1997	Caro et al.
5,590,652	A	1/1997	Inai
5,595,176	A	1/1997	Yamaura
5,596,992	A	1/1997	Haaland et al.
5,602,924	A	2/1997	Durand et al.
5,603,623	A	2/1997	Nishikawa et al.
5,630,413	A	5/1997	Thomas et al.
5,632,272	A	5/1997	Diab et al.
5,638,816	A	6/1997	Kiani-Azarbayjany et al.
5,638,818	A	6/1997	Diab et al.
5,645,059	A	7/1997	Fein et al.
5,645,060	A	7/1997	Yorkey
5,645,440	A	7/1997	Tobler et al.
5,660,567	A	8/1997	Nierlich et al.
5,662,106	A	9/1997	Swedlow et al.
5,676,139	A	10/1997	Goldberger et al.
5,676,141	A	10/1997	Hollub
5,678,544	A	10/1997	Delonzor et al.
5,685,299	A	11/1997	Diab et al.
5,685,301	A	11/1997	Klomhaus
5,687,719	A	11/1997	Sato et al.
5,687,722	A	11/1997	Tien et al.
5,690,104	A	11/1997	Kanemoto et al.
5,692,503	A	12/1997	Kuenstner
5,697,371	A	12/1997	Aoyagi
5,713,355	A	2/1998	Richardson et al.
5,719,589	A	2/1998	Norman et al.
5,720,284	A	2/1998	Aoyagi et al.
D393,830	S	4/1998	Tobler et al.
5,743,262	A	4/1998	Lepper, Jr. et al.
5,743,263	A	4/1998	Baker, Jr.
5,746,206	A	5/1998	Mannheimer
5,746,697	A	5/1998	Swedlow et al.
5,752,914	A	5/1998	Delonzor et al.
5,755,226	A	5/1998	Carim et al.
5,758,644	A	6/1998	Diab et al.
5,760,910	A	6/1998	Lepper, Jr. et al.
5,769,785	A	6/1998	Diab et al.
5,772,587	A	6/1998	Gratton et al.
5,779,630	A	7/1998	Fein et al.
5,782,237	A	7/1998	Casciani et al.
5,782,756	A	7/1998	Mannheimer
5,782,757	A	7/1998	Diab et al.
5,785,659	A	7/1998	Caro et al.
5,790,729	A	8/1998	Pologe et al.
5,791,347	A	8/1998	Flaherty et al.
5,792,052	A	8/1998	Isaacson et al.
5,793,485	A	8/1998	Gourley
5,800,348	A	9/1998	Kaestle
5,800,349	A	9/1998	Isaacson et al.
5,803,910	A	9/1998	Potratz
5,807,246	A	9/1998	Sakaguchi et al.
5,807,247	A	9/1998	Merchant et al.
5,810,723	A	9/1998	Aldrich
5,810,724	A	9/1998	Gronvall

5,810,734	A		9/1998	Caro et al.
5,817,010	A		10/1998	Hibl
5,818,985	A		10/1998	Merchant et al.
5,823,950	A		10/1998	Diab et al.
5,823,952	A		10/1998	Levinson et al.
5,827,182	A		10/1998	Raley
5,830,131	A		11/1998	Caro et al.
5,830,137	A		11/1998	Scharf
5,833,618	A		11/1998	Caro et al.
5,839,439	A		11/1998	Nierlich et al.
RE36,000	E		12/1998	Swedlow et al.
5,842,979	A	*	12/1998	Jarman 600/322
5,851,178	A		12/1998	Aronow
5,851,179	A		12/1998	Ritson et al.
5,853,364	A		12/1998	Baker, Jr. et al.
5,857,462	A		1/1999	Thomas et al.
5,860,919	A		1/1999	Kiani-Azarbayjany et al.
5,865,736	A		2/1999	Baker, Jr. et al.
5,876,348	A		3/1999	Sugo
5,885,213	A		3/1999	Richardson et al.
5,890,929	A		4/1999	Mills et al.
5,891,022	A		4/1999	Pologe
5,891,024	A		4/1999	Jarman et al.
5,904,654	A		5/1999	Wohltmann et al.
5,910,108	A		6/1999	Solenberger
5,916,154	A		6/1999	Hobbs et al.
5,919,133	A		7/1999	Taylor
5,919,134	A		7/1999	Diab
5,921,921	A		7/1999	Potratz et al.
5,934,277	A		8/1999	Mortz
5,934,925	A		8/1999	Tobler et al.
5,940,182	A		8/1999	Lepper, Jr. et al.
5,954,644	A		9/1999	Dettling
5,978,691	A		11/1999	Mills
5,983,122	A		11/1999	Jarman et al.
5,995,855	A		11/1999	Kiani et al.
5,995,856	A		11/1999	Mannheimer et al.
5,995,859	A		11/1999	Takahashi
5,997,343	A		12/1999	Mills et al.
5,999,841	A		12/1999	Aoyagi et al.
6,002,952	A		12/1999	Diab et al.
6,006,119	A		12/1999	Soller et al.
6,011,986	A		1/2000	Diab et al.
6,014,576	A		1/2000	Raley
6,018,673	A		1/2000	Chin et al.
6,018,674	A		1/2000	Aronow
6,023,541	A		2/2000	Merchant et al.
6,027,452	A		2/2000	Flaherty et al.
6,036,642	A		3/2000	Diab et al.
6,045,509	A		4/2000	Caro et al.
6,064,898	A		5/2000	Aldrich
6,067,462	A		5/2000	Diab et al.
6,068,594	A		5/2000	Schloemer et al.
6,073,037	A		6/2000	Alam et al.
6,081,735	A		6/2000	Diab et al.
6,083,172	A		7/2000	Baker, Jr. et al.
6,088,607	A		7/2000	Diab et al.
6,094,592	A		7/2000	Yorkey et al.
6,104,938	A		8/2000	Huiku
6,110,522	A		8/2000	Lepper, Jr. et al.
6,112,107	A		8/2000	Hannula
6,122,042	A		9/2000	Wunderman et al.
6,124,597	A		9/2000	Shehada et al.
6,144,868	A		11/2000	Parker
6,149,588	A		11/2000	Noda et al.
6,151,516	A		11/2000	Kiani-Azarbayjany et al.
6,151,518	A		11/2000	Hayashi
6,152,754	A		11/2000	Gerhardt et al.
6,154,667	A		11/2000	Miura et al.
6,157,041	A		12/2000	Thomas et al.
6,157,850	A		12/2000	Diab et al.
6,165,005	A		12/2000	Mills et al.
6,174,283	B1		1/2001	Nevo et al.
6,184,521	B1		2/2001	Coffin, IV et al.
6,192,261	B1		2/2001	Gratton et al.
6,206,830	B1		3/2001	Diab et al.
6,226,539	B1		5/2001	Potratz
6,229,856	B1		5/2001	Diab et al.
6,230,035	B1		5/2001	Aoyagi et al.
6,232,609	B1		5/2001	Snyder et al.
6,236,872	B1		5/2001	Diab et al.
6,241,683	B1		6/2001	Macklem et al.
6,253,097	B1		6/2001	Aronow et al.
6,256,523	B1		7/2001	Diab et al.
6,262,698	B1		7/2001	Blum
6,263,222	B1		7/2001	Diab et al.
6,272,363	B1		8/2001	Casciani et al.
6,278,522	B1		8/2001	Lepper, Jr. et al.
6,280,213	B1		8/2001	Tobler et al.
6,285,895	B1		9/2001	Ristolainen et al.
6,285,896	B1		9/2001	Tobler et al.
6,298,252	B1		10/2001	Kovach et al.
6,304,675	B1		10/2001	Osbourn et al.
6,304,767	B1		10/2001	Soller et al.
6,321,100	B1		11/2001	Parker
6,330,468	B1		12/2001	Scharf
6,334,065	B1		12/2001	Al-Ali et al.
6,341,257	B1		1/2002	Haaland
6,343,224	B1		1/2002	Parker
6,349,228	B1		2/2002	Kiani et al.
6,351,658	B1		2/2002	Middleman et al.
6,356,774	B1		3/2002	Bernstein et al.
6,360,113	B1		3/2002	Dettling
6,360,114	B1		3/2002	Diab et al.
6,363,269	B1		3/2002	Hanna et al.
6,368,283	B1		4/2002	Xu et al.
6,371,921	B1		4/2002	Caro et al.
6,374,129	B1		4/2002	Chin et al.
6,377,828	B1		4/2002	Chaiken et al.
6,377,829	B1		4/2002	Al-Ali
6,388,240	B2		5/2002	Schulz et al.
6,393,310	B1		5/2002	Kuenstner
6,397,091	B2		5/2002	Diab et al.
6,397,092	B1		5/2002	Norris et al.
6,397,093	B1	*	5/2002	Aldrich 600/330
6,408,198	B1		6/2002	Hanna et al.
6,411,833	B1		6/2002	Baker, Jr. et al.
6,415,166	B1		7/2002	Van Hoy et al.
6,415,233	B1		7/2002	Haaland
6,415,236	B2		7/2002	Kobayashi et al.
6,430,525	B1		8/2002	Weber et al.
6,434,408	B1		8/2002	Heckel
6,441,388	B1		8/2002	Thomas et al.
6,453,184	B1		9/2002	Hyogo et al.
6,455,340	B1		9/2002	Chua et al.
6,463,310	B1		10/2002	Swedlow et al.
6,463,311	B1		10/2002	Diab
6,466,824	B1		10/2002	Struble
6,470,199	B1		10/2002	Kopotic et al.
6,480,729	B2		11/2002	Stone
6,490,466	B1		12/2002	Fein et al.
6,497,659	B1		12/2002	Rafert
6,501,974	B2		12/2002	Huiku
6,501,975	B2		12/2002	Diab et al.
6,504,943	B1		1/2003	Sweatt et al.
6,505,059	B1		1/2003	Kollias et al.
6,505,060	B1		1/2003	Norris
6,505,061	B2		1/2003	Larson
6,505,133	B1		1/2003	Hanna
6,510,329	B2		1/2003	Heckel
6,515,273	B2		2/2003	Al-Ali
6,519,486	B1		2/2003	Edgar, Jr. et al.
6,519,487	B1		2/2003	Parker
6,522,398	B2		2/2003	Cadell et al.
6,525,386	B1		2/2003	Mills et al.
6,526,300	B1		2/2003	Kiani et al.
6,526,301	B2		2/2003	Larsen et al.
6,528,809	B1		3/2003	Thomas et al.
6,537,225	B1		3/2003	Mills
6,541,756	B2		4/2003	Schulz et al.
6,542,763	B1	*	4/2003	Yamashita et al. 600/310
6,542,764	B1		4/2003	Al-Ali et al.
6,545,652	B1		4/2003	Tsuji
6,546,267	B1		4/2003	Sugiura
6,553,241	B2		4/2003	Mannheimer et al.
6,564,077	B2		5/2003	Mortara
6,571,113	B1		5/2003	Fein et al.
6,580,086	B1		6/2003	Schulz et al.

6,582,964 B1 6/2003 Samsoondar et al.
6,584,336 B1 6/2003 Ali et al.
6,584,413 B1 6/2003 Keenan et al.
6,591,123 B2 7/2003 Fein et al.
6,594,511 B2 7/2003 Stone et al.
6,595,316 B2 7/2003 Cybulski et al.
6,597,932 B2 7/2003 Tian et al.
6,597,933 B2 7/2003 Kiani et al.
6,600,940 B1 7/2003 Fein et al.
6,606,509 B2 8/2003 Schmitt
6,606,510 B2 8/2003 Swedlow et al.
6,606,511 B1 8/2003 Ali et al.
6,611,698 B1 8/2003 Yamashita et al.
6,614,521 B2 9/2003 Samsoondar et al.
6,615,064 B1 9/2003 Aldrich
6,615,151 B1 9/2003 Scecina et al.
6,618,602 B2 9/2003 Levin
6,622,095 B2 9/2003 Kobayashi et al.
6,628,975 B1 9/2003 Fein et al.
6,631,281 B1 10/2003 Kastle
6,632,181 B2 10/2003 Flaherty et al.
6,639,668 B1 10/2003 Trepagnier
6,640,116 B2 10/2003 Diab
6,643,530 B2 11/2003 Diab et al.
6,650,917 B2 11/2003 Diab et al.
6,654,623 B1 11/2003 Kastle
6,654,624 B2 11/2003 Diab et al.
6,657,717 B2 12/2003 Cadell et al.
6,658,276 B2 12/2003 Kianl et al.
6,658,277 B2 12/2003 Wasserman
6,661,161 B1 12/2003 Lanzo et al.
6,662,033 B2 12/2003 Casciani et al.
6,665,551 B1 12/2003 Suzuki
6,668,183 B2 12/2003 Hicks et al.
6,671,526 B1 12/2003 Aoyagi et al.
6,671,531 B2 12/2003 Al-Ali et al.
6,675,031 B1 1/2004 Porges et al.
6,675,106 B1 1/2004 Keenan et al.
6,678,543 B2 1/2004 Diab et al.
6,681,126 B2 1/2004 Solenberger
6,684,090 B2 1/2004 Ali et al.
6,684,091 B2 1/2004 Parker
6,687,620 B1 2/2004 Haaland et al.
6,690,466 B2 2/2004 Miller et al.
6,694,157 B1 2/2004 Stone et al.
6,697,655 B2 2/2004 Sueppel et al.
6,697,656 B1 2/2004 Al-Ali
6,697,657 B1 2/2004 Shehada et al.
6,697,658 B2 2/2004 Al-Ali
RE38,476 E 3/2004 Diab et al.
6,699,194 B1 3/2004 Diab et al.
6,701,170 B2 3/2004 Stetson
6,708,049 B1 3/2004 Berson et al.
6,711,503 B2 3/2004 Haaland
6,714,803 B1 3/2004 Mortz
6,714,804 B2 3/2004 Al-Ali et al.
6,714,805 B2 3/2004 Jeon et al.
RE38,492 E 4/2004 Diab et al.
6,719,705 B2 4/2004 Mills
6,720,734 B2 4/2004 Norris
6,721,582 B2 4/2004 Trepagnier et al.
6,721,584 B2 4/2004 Baker, Jr. et al.
6,721,585 B1 4/2004 Parker
6,725,074 B1 4/2004 Kastle
6,725,075 B2 4/2004 Al-Ali
6,726,634 B2 4/2004 Freeman
6,728,560 B2 4/2004 Kollias et al.
6,735,459 B2 5/2004 Parker
6,741,875 B1 5/2004 Pawluczyk et al.
6,741,876 B1 5/2004 Scecina et al.
6,743,172 B1 6/2004 Blike
6,745,060 B2 6/2004 Diab et al.
6,745,061 B1 6/2004 Hicks et al.
6,748,253 B2 6/2004 Norris et al.
6,748,254 B2 6/2004 Chin et al.
6,754,515 B1 6/2004 Pologe
6,754,516 B2 6/2004 Mannheimer
6,760,607 B2 7/2004 Al-All
6,760,609 B2 7/2004 Jacques
6,770,028 B1 8/2004 Ali et al.
6,771,994 B2 8/2004 Kiani et al.
6,773,397 B2 8/2004 Kelly
6,778,923 B2 8/2004 Norris et al.
6,780,158 B2 8/2004 Yarita
6,788,849 B1 9/2004 Pawluczyk
6,792,300 B1 9/2004 Diab et al.
6,800,373 B2 10/2004 Corczyca
6,801,797 B2 10/2004 Mannheimer et al.
6,801,799 B2 10/2004 Mendelson
6,810,277 B2 10/2004 Edgar, Jr. et al.
6,813,511 B2 11/2004 Diab et al.
6,816,741 B2 11/2004 Diab
6,819,950 B2 11/2004 Mills
6,822,564 B2 11/2004 Al-Ali
6,825,619 B2 11/2004 Norris
6,826,419 B2 11/2004 Diab et al.
6,829,496 B2 12/2004 Nagai et al.
6,829,501 B2 12/2004 Nielsen et al.
6,830,711 B2 12/2004 Mills et al.
6,836,679 B2 12/2004 Baker, Jr. et al.
6,839,579 B1 1/2005 Chin
6,839,580 B2 1/2005 Zonios et al.
6,839,582 B2 1/2005 Heckel
6,842,702 B2 1/2005 Haaland et al.
6,845,256 B2 1/2005 Chin et al.
6,847,835 B1 1/2005 Yamanishi
6,850,787 B2 2/2005 Weber et al.
6,850,788 B2 2/2005 Al-Ali
6,852,083 B2 2/2005 Caro et al.
6,861,639 B2 3/2005 Al-Ali
6,861,641 B1 3/2005 Adams
6,869,402 B2 3/2005 Arnold
6,882,874 B2 4/2005 Huiku
6,898,452 B2 5/2005 Al-Ali et al.
6,912,049 B2 6/2005 Pawluczyk et al.
6,917,422 B2 7/2005 Samsoondar et al.
6,919,566 B1 7/2005 Cadell
6,920,345 B2 7/2005 Al-Ali et al.
6,921,367 B2 7/2005 Mills
6,922,645 B2 7/2005 Haaland et al.
6,928,311 B1 8/2005 Pawluczyk et al.
6,931,268 B1 8/2005 Kiani-Azarbayjany et al.
6,931,269 B2 8/2005 Terry
6,934,570 B2 8/2005 Kiani et al.
6,939,305 B2 9/2005 Flaherty et al.
6,943,348 B1 9/2005 Coffin, IV
6,944,487 B2 9/2005 Maynard et al.
6,950,687 B2 9/2005 Al-Ali
6,956,572 B2 10/2005 Zaleski
6,961,598 B2 11/2005 Diab
6,970,792 B1 11/2005 Diab
6,975,891 B2 12/2005 Pawluczyk
6,979,812 B2 12/2005 Al-Ali
6,985,764 B2 1/2006 Mason et al.
6,987,994 B1 1/2006 Mortz
6,993,371 B2 1/2006 Kiani et al.
6,996,427 B2 2/2006 Ali et al.
6,999,904 B2 2/2006 Weber et al.
7,001,337 B2 2/2006 Dekker
7,003,338 B2 2/2006 Weber et al.
7,003,339 B2 2/2006 Diab et al.
7,006,856 B2 2/2006 Baker, Jr. et al.
7,015,451 B2 3/2006 Dalke et al.
7,024,233 B2 4/2006 Al et al.
7,027,849 B2 4/2006 Al-Ali
7,030,749 B2 4/2006 Al-Ali
7,039,449 B2 5/2006 Al-Ali
7,041,060 B2 5/2006 Flaherty et al.
7,044,918 B2 5/2006 Diab
7,067,893 B2 6/2006 Mills et al.
7,096,052 B2 8/2006 Mason et al.
7,096,054 B2 8/2006 Abdul-Hafiz et al.
7,132,641 B2 11/2006 Schulz et al.
7,142,901 B2 11/2006 Kiani et al.
7,149,561 B2 12/2006 Diab
7,186,966 B2 3/2007 Al-Ali
7,190,261 B2 3/2007 Al-Ali
7,215,984 B2 5/2007 Diab et al.

7,215,986	B2	5/2007	Diab et al.
7,221,971	B2	5/2007	Diab et al.
7,225,006	B2	5/2007	Al-Ali et al.
7,225,007	B2	5/2007	Al-Ali et al.
RE39,672	E	6/2007	Shehada et al.
7,239,905	B2	7/2007	Kiani-Azarbayjany et al.
7,245,953	B1	7/2007	Parker
7,254,429	B2	8/2007	Schurman et al.
7,254,431	B2	8/2007	Al-Ali et al.
7,254,433	B2	8/2007	Diab et al.
7,254,434	B2	8/2007	Schulz et al.
7,272,425	B2	9/2007	Al-Ali
7,274,955	B2	9/2007	Kiani et al.
D554,263	S	10/2007	Al-Ali et al.
7,280,858	B2	10/2007	Al-Ali et al.
7,289,835	B2	10/2007	Mansfield et al.
7,292,883	B2	11/2007	De Felice et al.
7,295,866	B2	11/2007	Al-Ali
7,299,080	B2	11/2007	Acosta et al.
7,328,053	B1	2/2008	Diab et al.
7,332,784	B2	2/2008	Mills et al.
7,340,287	B2	3/2008	Mason et al.
7,341,559	B2	3/2008	Schulz et al.
7,343,186	B2	3/2008	Lamego et al.
D566,282	S	4/2008	Al-Ali et al.
7,355,512	B1	4/2008	Al-Ali
7,356,365	B2	4/2008	Schurman
7,371,981	B2	5/2008	Abdul-Hafiz
7,373,193	B2	5/2008	Al-Ali et al.
7,373,194	B2	5/2008	Weber et al.
7,376,453	B1	5/2008	Diab et al.
7,377,794	B2	5/2008	Al-Ali et al.
7,377,899	B2	5/2008	Weber et al.
7,383,070	B2	6/2008	Diab et al.
7,415,297	B2	8/2008	Al-Ali et al.
7,428,432	B2	9/2008	Ali et al.
7,438,683	B2	10/2008	Al-Ali et al.
7,440,787	B2	10/2008	Diab
7,454,240	B2	11/2008	Diab et al.
7,467,002	B2	12/2008	Weber et al.
7,469,157	B2	12/2008	Diab et al.
7,471,969	B2	12/2008	Diab et al.
7,471,971	B2	12/2008	Diab et al.
7,483,729	B2	1/2009	Al-Ali et al.
7,483,730	B2	1/2009	Diab et al.
7,489,958	B2	2/2009	Diab et al.
7,496,391	B2	2/2009	Diab et al.
7,496,393	B2	2/2009	Diab et al.
D587,657	S	3/2009	Al-Ali et al.
7,499,741	B2	3/2009	Diab et al.
7,499,835	B2	3/2009	Weber et al.
7,500,950	B2	3/2009	Al-Ali et al.
7,509,154	B2	3/2009	Diab et al.
7,509,494	B2	3/2009	Al-Ali
7,510,849	B2	3/2009	Schurman et al.
7,526,328	B2	4/2009	Diab et al.
7,530,942	B1	5/2009	Diab
7,530,949	B2	5/2009	Al Ali et al.
7,530,955	B2	5/2009	Diab et al.
7,563,110	B2	7/2009	Al-Ali et al.
7,596,398	B2	9/2009	Al-Ali et al.
7,618,375	B2	11/2009	Flaherty et al.
D606,659	S	12/2009	Kiani et al.
7,647,083	B2	1/2010	Al-Ali et al.
D609,193	S	2/2010	Al-Ali et al.
D614,305	S	4/2010	Al-Ali et al.
RE41,317	E	5/2010	Parker
7,729,733	B2	6/2010	Al-Ali et al.
7,734,320	B2	6/2010	Al-Ali
7,899,507	B2	3/2011	Al-Ali et al.
7,957,780	B2	6/2011	Lamego et al.
2001/0044700	A1	11/2001	Koboyashi et al.
2001/0045532	A1	11/2001	Schulz et al.
2002/0021269	A1	2/2002	Rast
2002/0026107	A1	2/2002	Kiani et al.
2002/0035318	A1	3/2002	Mannheimer et al.
2002/0038078	A1	3/2002	Ito
2002/0038081	A1	3/2002	Fein et al.
2002/0059047	A1	5/2002	Haaland
2002/0082488	A1	6/2002	Al-Ali et al.
2002/0095078	A1	7/2002	Mannheimer et al.
2002/0111748	A1	8/2002	Kobayashi et al.
2002/0115919	A1	8/2002	Al-Ali
2002/0154665	A1	10/2002	Funabashi et al.
2002/0156353	A1	10/2002	Larson
2002/0159002	A1	10/2002	Chang
2002/0161291	A1*	10/2002	Kianl et al. 600/324
2002/0165440	A1	11/2002	Mason et al.
2002/0183819	A1	12/2002	Struble
2003/0045784	A1	3/2003	Palatnik et al.
2003/0045785	A1	3/2003	Diab et al.
2003/0049232	A1	3/2003	Page et al.
2003/0109775	A1	6/2003	O'Neil et al.
2003/0116769	A1	6/2003	Song et al.
2003/0117296	A1	6/2003	Seely
2003/0120160	A1	6/2003	Yarita
2003/0120164	A1*	6/2003	Nielsen et al. 600/513
2003/0135099	A1	7/2003	Al-Ali
2003/0139657	A1	7/2003	Solenberger
2003/0160257	A1	8/2003	Bader et al.
2003/0195402	A1	10/2003	Fein et al.
2004/0006261	A1	1/2004	Swedlow et al.
2004/0033618	A1	2/2004	Haass et al.
2004/0034898	A1	2/2004	Bruegl
2004/0059209	A1	3/2004	Al-Ali et al.
2004/0064259	A1	4/2004	Haaland et al.
2004/0081621	A1	4/2004	Arndt et al.
2004/0092805	A1	5/2004	Yarita
2004/0133087	A1	7/2004	Ali et al.
2004/0138538	A1	7/2004	Stetson
2004/0138540	A1	7/2004	Baker, Jr. et al.
2004/0147822	A1	7/2004	Al-Ali et al.
2004/0147823	A1	7/2004	Kiani et al.
2004/0158132	A1	8/2004	Zaleski
2004/0158134	A1	8/2004	Diab et al.
2004/0158135	A1	8/2004	Baker, Jr. et al.
2004/0162472	A1	8/2004	Berson et al.
2004/0167382	A1	8/2004	Gardner et al.
2004/0176670	A1	9/2004	Takamura et al.
2004/0181134	A1	9/2004	Baker, Jr. et al.
2004/0199063	A1	10/2004	O'Neil et al.
2004/0204639	A1	10/2004	Casciani et al.
2004/0204868	A1	10/2004	Maynard et al.
2004/0229391	A1	11/2004	Ohya et al.
2004/0262046	A1*	12/2004	Simond et al. 177/25.13
2004/0267103	A1	12/2004	Li et al.
2004/0267140	A1	12/2004	Ito et al.
2005/0011488	A1	1/2005	Doucet
2005/0033128	A1	2/2005	Ali et al.
2005/0043902	A1	2/2005	Haaland et al.
2005/0049469	A1	3/2005	Aoyagi et al.
2005/0054908	A1	3/2005	Blank et al.
2005/0070773	A1	3/2005	Chin et al.
2005/0070775	A1	3/2005	Chin et al.
2005/0075546	A1	4/2005	Samsoondar et al.
2005/0085704	A1	4/2005	Schulz et al.
2005/0085735	A1	4/2005	Baker et al.
2005/0124871	A1	6/2005	Baker et al.
2005/0143634	A1	6/2005	Baker et al.
2005/0143943	A1	6/2005	Brown
2005/0148834	A1	7/2005	Hull et al.
2005/0184895	A1	8/2005	Petersen et al.
2005/0187447	A1	8/2005	Chew et al.
2005/0187448	A1	8/2005	Petersen et al.
2005/0187449	A1	8/2005	Chew et al.
2005/0187450	A1	8/2005	Chew et al.
2005/0187452	A1	8/2005	Petersen et al.
2005/0187453	A1	8/2005	Petersen et al.
2005/0197549	A1	9/2005	Baker Jr.
2005/0197579	A1	9/2005	Baker Jr.
2005/0197793	A1	9/2005	Baker Jr.
2005/0203357	A1	9/2005	Debreczeny et al.
2005/0209515	A1	9/2005	Hockersmith et al.
2005/0228253	A1	10/2005	Debreczeny
2005/0250997	A1	11/2005	Takeda et al.
2006/0030764	A1	2/2006	Porges et al.
2006/0210120	A1	9/2006	Rowe et al.
2006/0211922	A1	9/2006	Al-Ali et al.

2006/0211923	A1	9/2006	Al-Ali et al.
2006/0211924	A1	9/2006	Smith et al.
2006/0211925	A1	9/2006	Lamego et al.
2006/0211932	A1	9/2006	Al-Ali et al.
2006/0226992	A1	10/2006	Al-Ali et al.
2006/0229509	A1	10/2006	Al-Ali et al.
2006/0238358	A1	10/2006	Al-Ali et al.
2006/0241358	A1	10/2006	Al-Ali et al.
2006/0241363	A1	10/2006	Al-Ali et al.
2011/0009719	A1	1/2011	Al-Ali et al.
2011/0237914	A1	9/2011	Lamego et al.

FOREIGN PATENT DOCUMENTS

EP	0 675 541		10/1995
EP	1 895 892		5/2010
EP	2 305 104		4/2011
JP	61-28172		2/1986
JP	63-275327		11/1988
JP	64-500495		2/1989
JP	2-145457		12/1990
JP	05-207993		8/1993
JP	6-505903		7/1994
JP	6-237013		8/1994
JP	7-281618		10/1995
JP	07-325546		12/1995
JP	9-192120		7/1997
JP	10-216112		8/1998
JP	10-509352		9/1998
JP	10-269344	A	10/1998
JP	10-295676		11/1998
JP	10-305026		11/1998
JP	11-163412		6/1999
JP	11-164826		6/1999
JP	11-506834		6/1999
JP	11-183377		7/1999
JP	2000-116625		4/2000
JP	2002-516689		6/2002
JP	2002-228579		8/2002
JP	2002-525151		8/2002
JP	2002-315739		10/2002
JP	2003-507718		2/2003
JP	2003-084108		3/2003
JP	2003-521985		7/2003
JP	2004-070179		3/2004
JP	2004-226277		8/2004
JP	2004-296736		10/2004
JP	2004-532526		10/2004
JP	2004-327760		11/2004
JP	2005-501589		1/2005
JP	2005-253478		9/2005
JP	4879913		12/2011
WO	WO 88/01150		2/1988
WO	WO 88/02020		2/1988
WO	WO 92/16142		10/1992
WO	WO 95/16387		6/1995
WO	WO 96/13208		5/1996
WO	WO 97/01985		1/1997
WO	WO 98/43071		10/1998
WO	WO 98-43071		10/1998
WO	WO 00/18290		4/2000
WO	WO 00/42911	A1	7/2000
WO	WO 00/59374		10/2000
WO	WO 01/13790		3/2001
WO	WO 01/30414		5/2001
WO	WO 01/58347		8/2001
WO	WO 02/17780		3/2002
WO	WO 02/26123		4/2002
WO	WO 02/089664		11/2002
WO	WO 03/020129		3/2003
WO	WO 03/068060		8/2003
WO	WO 03-068060		8/2003
WO	WO 2004/034898		4/2004
WO	WO 2005/011488		2/2005
WO	WO 2006/094168		9/2006

OTHER PUBLICATIONS

Schmitt, Joseph M.; Zhou, Guan-Xiong; Miller, Justin, *Measurement of Blood Hematocrit by Dual-wavelength Near-IR Photoplethysmography*, published May 1992, Proc. SPIE vol. 1641, p. 150-161, Physiological Monitoring and Early Detection Diagnostic Methods, Thomas S. Mang; Ed. (SPIE homepage), in 12 pages.

Patent Cooperation Treaty (PCT) International Search Report; PCT/US 2006/007389; Date of Mailing Jul. 17, 2006; pp. 1-9.

PCT International Search Report; PCT/US2006/007537; Date of Mailing Jul. 17, 2006; pp. 1-10.

PCT International Search Report; PCT/US2006/007388; Date of Mailing Jul. 17, 2006; pp. 1-9.

PCT International Search Report; PCT/US2006/007538; Date of Mailing Jul. 17, 2006; pp. 1-9.

PCT International Search Report; PCT/US2006/007958; Date of Mailing Jul. 17, 2006; pp. 1-8.

PCT International Search Report; PCT/US2006/007536; Date of Mailing Jul. 17, 2006; pp. 1-9.

PCT International Search Report; PCT/US2006/007540; Date of Mailing Jul. 17, 2006; pp. 1-9.

PCT International Search Report; PCT/US2006/007539; Date of Mailing Jul. 17, 2006; pp. 1-9.

PCT International Search Report; PCT/US2006/007387; Date of Mailing Jul. 17, 2006; pp. 1-9.

Burritt, Mary F.; Current Analytical Approaches to Measuring Blood Analytes; vol. 36; No. 8(B); 1990.

European Examination Report dated Mar. 18, 2011, re EP App. No. 08 744 412.1-2319.

European Examination Report dated Sep. 2, 2010, re EP App. No. 08 744 412.1-2319.

European Extended Search Report re EPO App. No. 10162402.1, SR dated Aug. 9, 2010.

Hall, et al., Jeffrey W.; Near-Infrared Spectrophotometry: A New Dimension in Clinical Chemistry; vol. 38; No. 9; 1992.

Japanese First Office Action (Notice of Reasons for Rejection), re JP App. No. 2007-558207, dated Jun. 28, 2011.

Japanese First Office Action (Notice of Reasons for Rejection), re JP App. No. 2007-558247, dated Jun. 28, 2011.

Japanese Office Action (Notice of Reasons for Rejection) re JP App. No. 2007-558246, dated Jun. 28, 2011.

Japanese Office Action (Notice of Reasons for Rejection), re JP App. No. 2007-558238, dated Jun. 28, 2011.

Japanese Office Action re JP Application No. 2007-558249, dated Jul. 13, 2011.

Japanese Office Action, re JP Application No. 2007-558237, dated Aug. 1, 2011.

Kuenstner, et al., J. Todd; Measurement of Hemoglobin in Unlysed Blood by Near-Infrared Spectroscopy; vol. 48; No. 4, 1994.

Manzke, et al., B., Multi Wavelength Pulse OXimetry in the Measurement of Hemoglobin Fractions; vol. 2676, date unknown.

Naumenko, E. K.; Choice of Wavelengths for Stable Determination of Concentrations of Hemoglobin Derivatives from Absorption Spectra of Erythrocytes; vol. 63; No. 1; pp. 60-66 Jan.-Feb. 1996; Original article submitted Nov. 3, 1994.

PCT Search Report of International Application No. PCT/US2008/058327, Mailing Date of Jun. 30, 2009, in 12 pages.

PCT Search Report of International Application No. PCT/US2008/058327, Mailing Date of Aug. 12, 2008, in 6 pages.

Schmitt, Joseph M.; Simple Photon Diffusion Anaylsis of the Effects of Multiple Scattering on Pulse Oximetry; Mar. 14, 1991; revised Aug. 30, 1991.

Schnapp, et al., L.M.; Pulse Oximetry. Uses and Abuses.; Chest 1990; 98; 1244-1250001 10.1378/Chest.98.5.1244.

European Examination Report dated Apr. 1, 2010, re EP App. No. 08 744 412.1 - 2319.

European Examination Report dated Mar. 18, 2011, re EP App. No. 08 744 412.1 - 2319.

International Search Report for PCT-US2006-007516, mailed on Jan. 11, 2007, in 4 pages.

Japanese Office Action (Notice of Allowance), re JP App. No. 2007-558247, dated Oct. 24, 2011.

Japanese Office Action re JP Application No. 2007-558249, dated Nov. 8, 2011.

Japanese Office Action re JP Application No. JP 2007-558208, dated Aug. 23, 2011.

Japanese Office Action re JP Application No. JP 2007-558248, dated Nov. 8, 2011.
Japanese Office Action re JP Application No. 2007-558209, dated Oct. 25, 2011.
Japanese Office Action re JP Application No. 2007-558245, dated Oct. 25, 2011.
Patent Cooperation Treaty (PCT) International Search Report; PCT-US 2006-007389; Date of Mailing Jul. 17, 2006; pp. 1-9.
PCT International Search Report; PCT/US2006/007506; Date of Mailing Jul. 17, 2006; pp. 1-10.

* cited by examiner

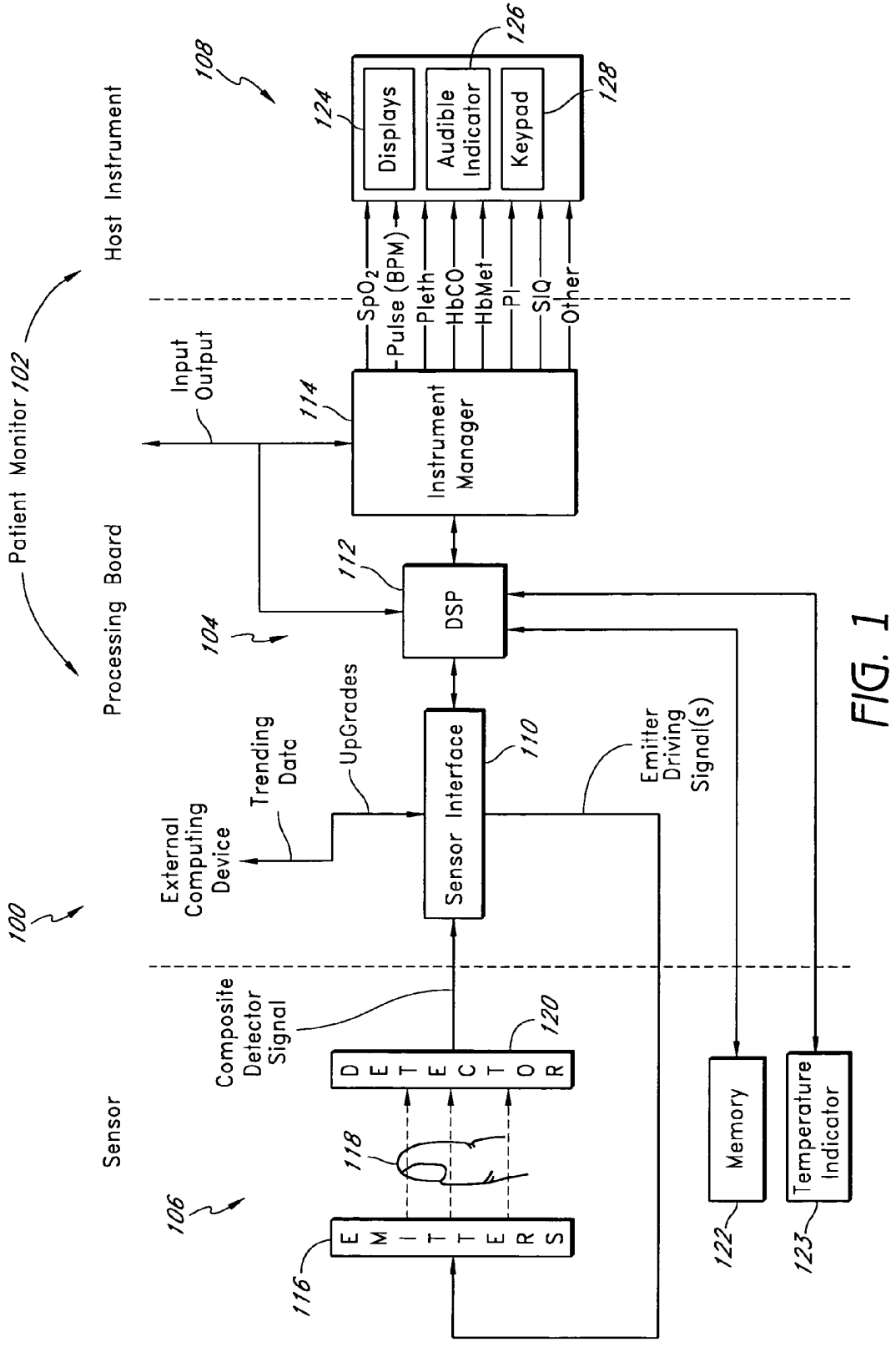

Patient Monitor 102
Host Instrument
Processing Board
Sensor
100
104
106
108
Displays
Audible Indicator
Keypad
124
126
128
SpO2
Pulse (BPM)
Pleth
HbCO
HbMet
PI
SIQ
Other
Input
Output
Instrument Manager
114
DSP
112
Trending Data
UpGrades
Sensor Interface
110
Emitter Driving Signal(s)
External Computing Device
Composite Detector Signal
DETECTOR
120
EMITTERS
116
118
Memory
122
Temperature Indicator
123

FIG. 1

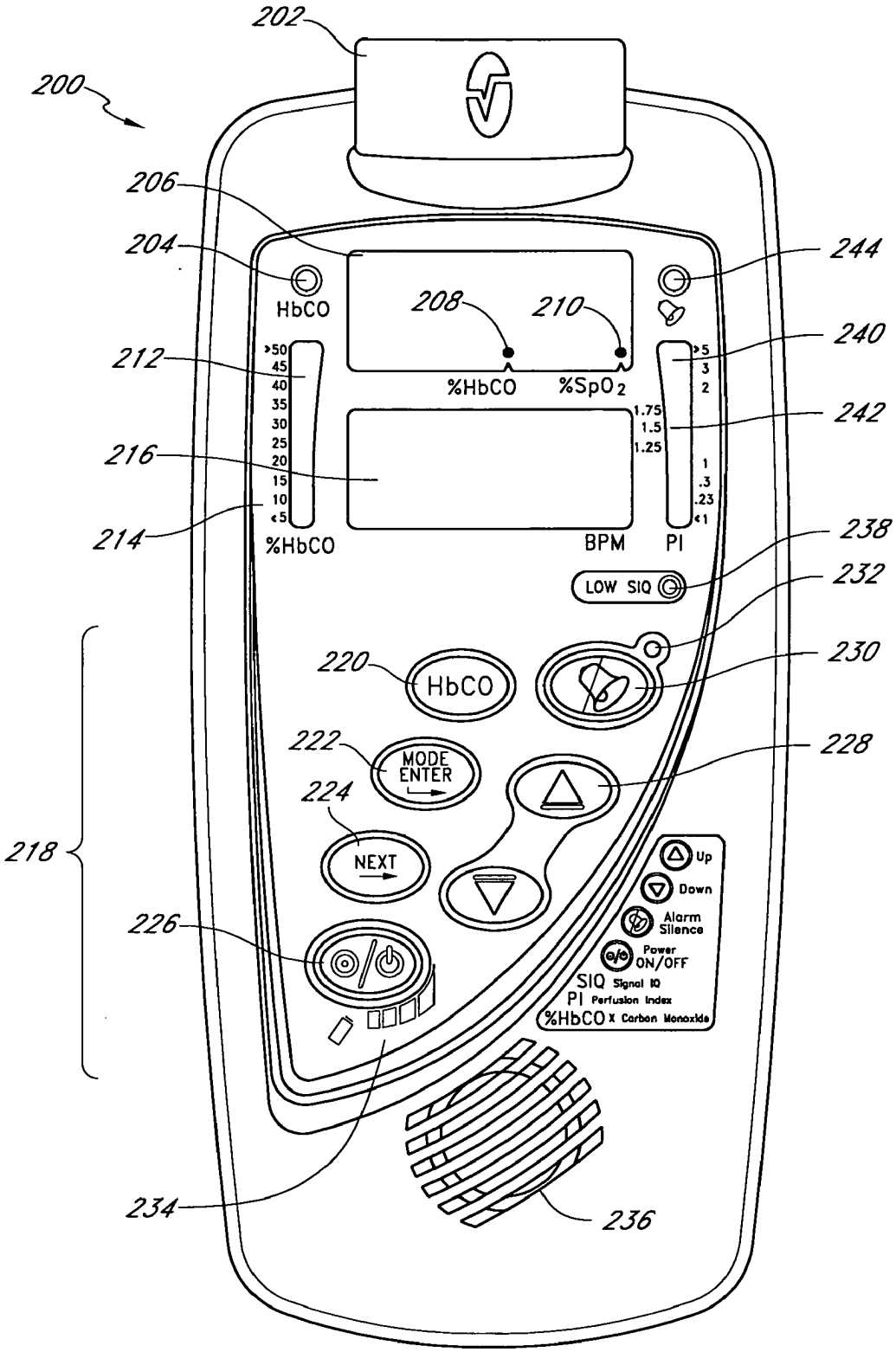

202
200
206
204
244
HbCO
208
210
240
212
%HbCO
%SpO2
242
216
214
238
LOW SIQ
232
220
HbCO
230
222
MODE ENTER
228
224
218
NEXT
Up
Down
Alarm Silence
Power ON/OFF
SIQ Signal IQ
PI Perfusion Index
%HbCO Carbon Monoxide
226
234
236

FIG. 2

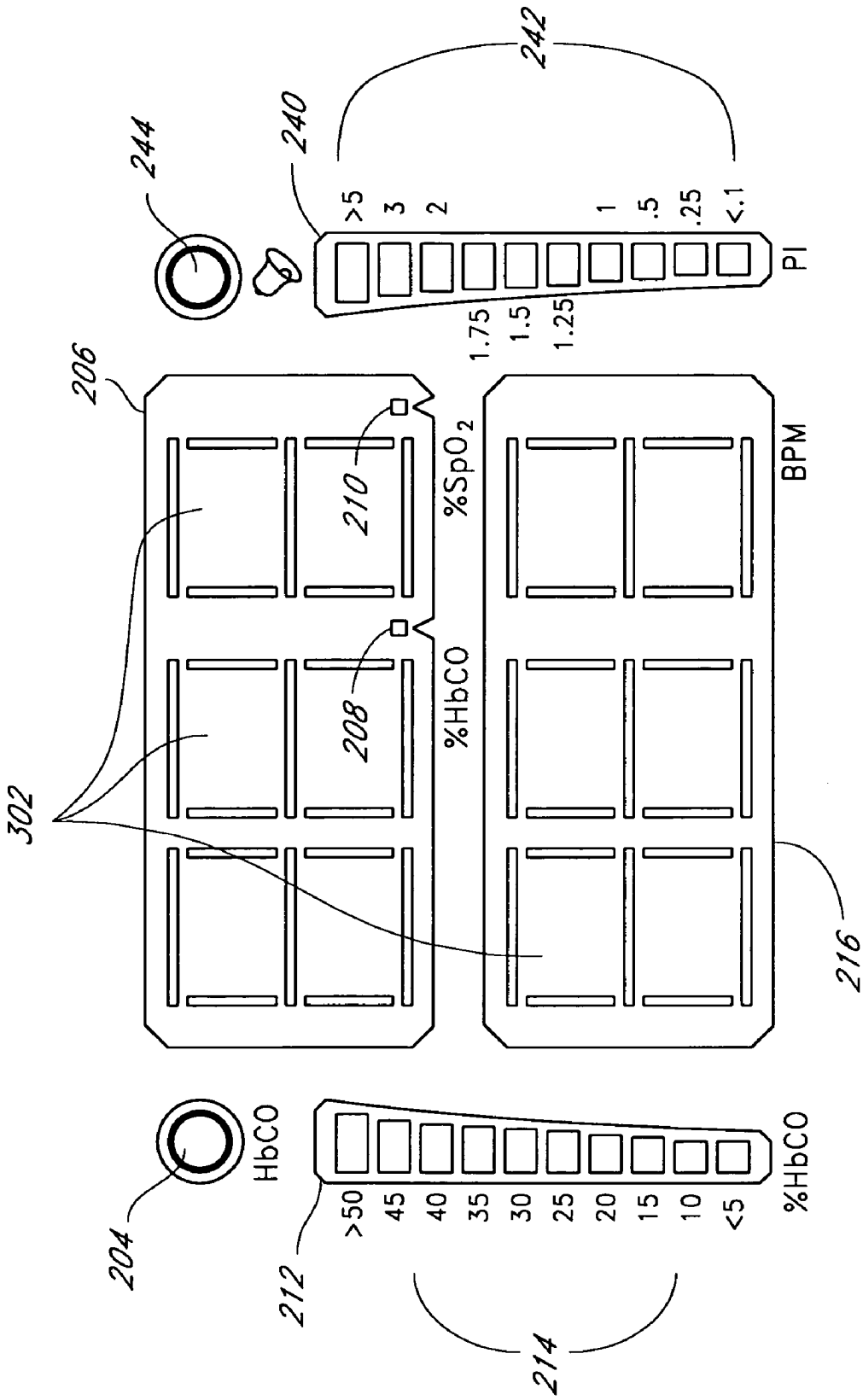

242
240
244
>5
3
2
1
.5
.25
<.1
PI
1.75
1.5
1.25
206
210
%SpO2
BPM
208
%HbCO
302
216
HbCO
204
>50
45
40
35
30
25
20
15
10
<5
%HbCO
212
214

FIG. 3

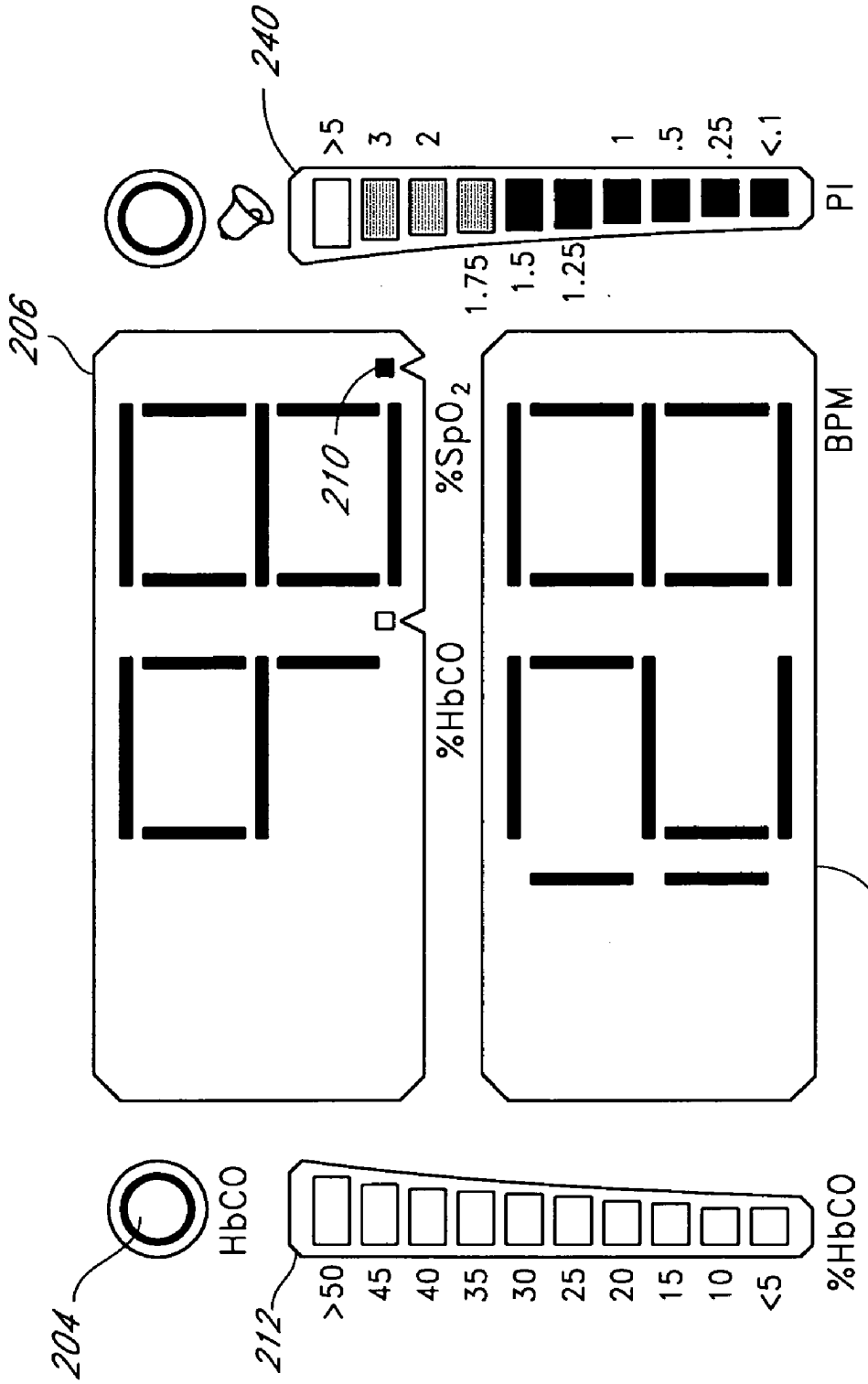

240
>5
3
2
1
.5
.25
<.1
PI
1.75
1.5
1.25
206
210
%SpO2
BPM
%HbCO
216
204
HbCO
212
>50
45
40
35
30
25
20
15
10
<5
%HbCO

FIG. 4

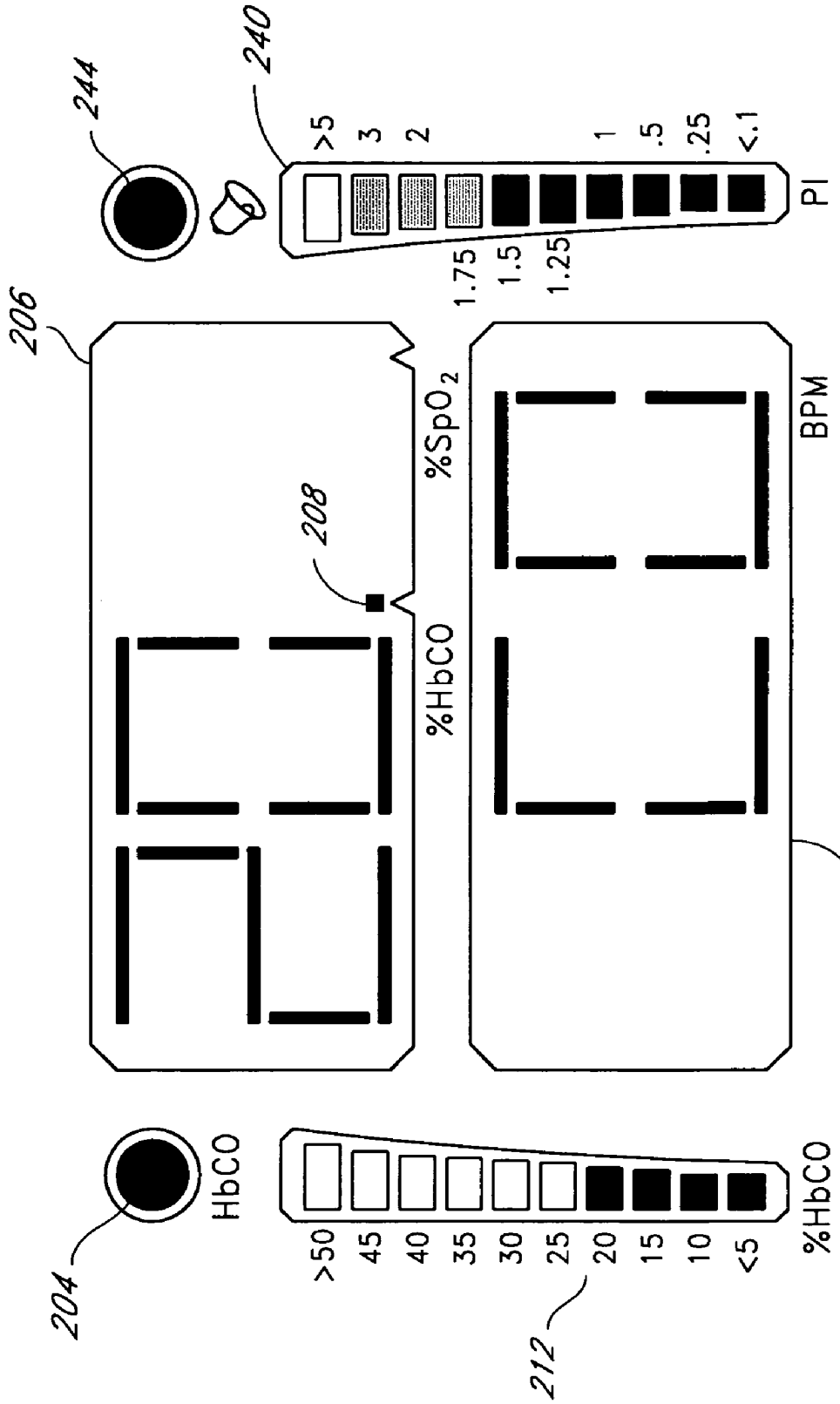

244
240
>5
3
2
1
.5
.25
<.1
PI
1.75
1.5
1.25
206
%SpO2
208
%HbCO
BPM
216
204
HbCO
>50
45
40
35
30
25
20
15
10
<5
%HbCO
212

FIG. 5

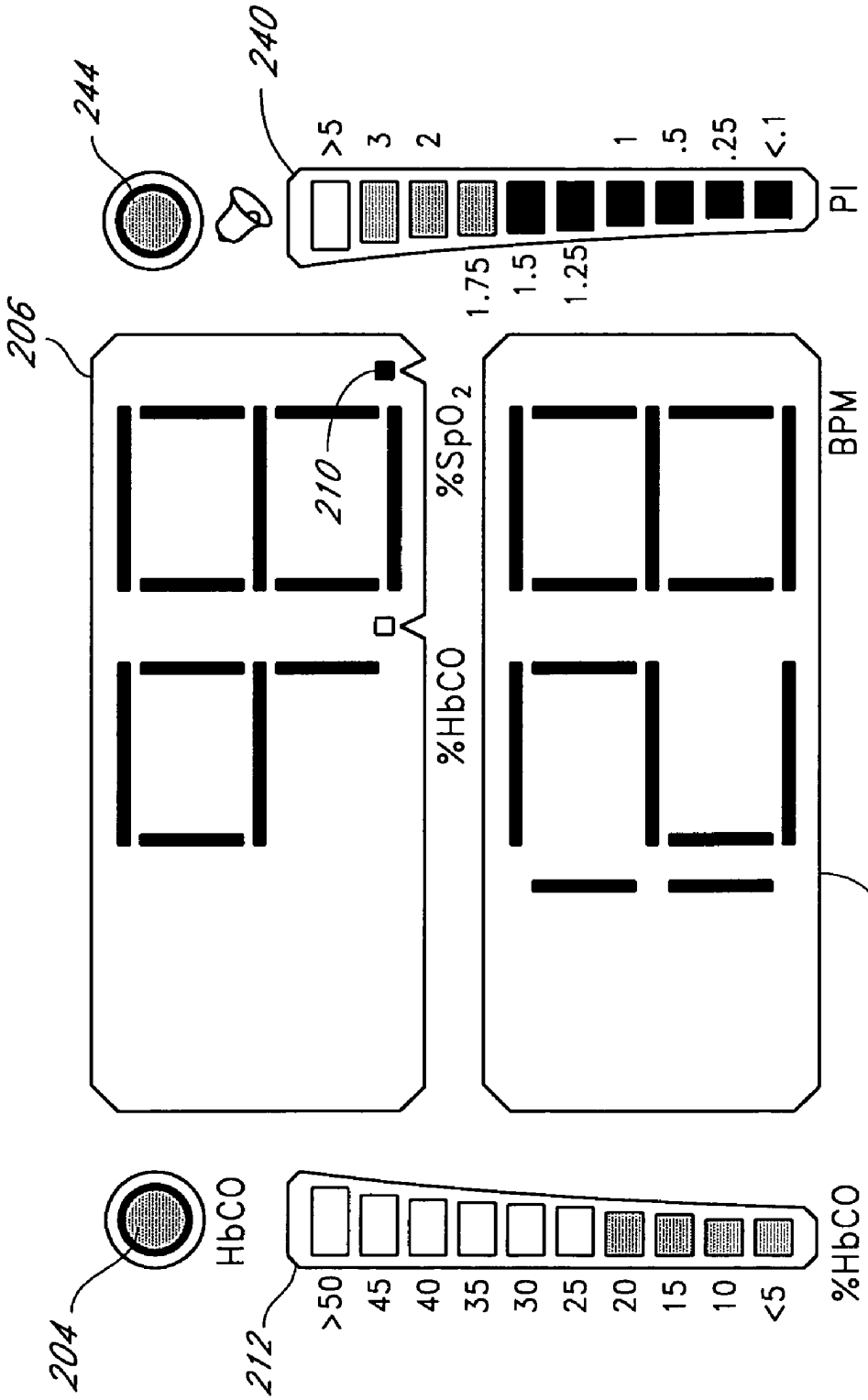

244
240
>5
3
2
1
.5
.25
<.1
PI
1.75
1.5
1.25
206
210
%SpO2
BPM
%HbCO
216
204
HbCO
212
>50
45
40
35
30
25
20
15
10
<5
%HbCO

FIG. 6

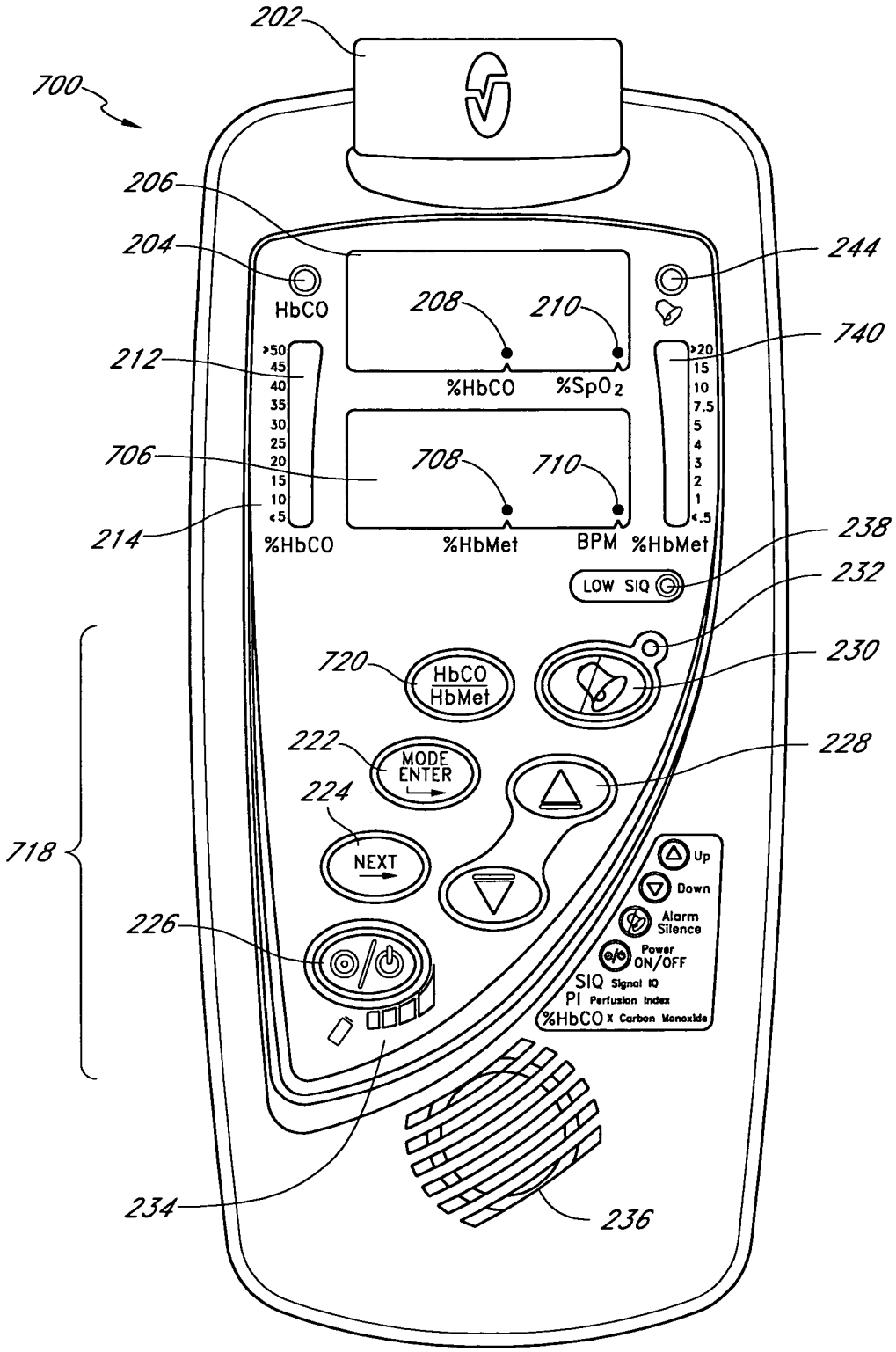

202
700
206
204
244
HbCO
208
210
740
212
%HbCO
%SpO2
706
708
710
214
%HbCO
%HbMet
BPM
%HbMet
238
LOW SIQ
232
720
HbCO
HbMet
230
222
MODE
ENTER
228
224
NEXT
718
Up
Down
Alarm
Silence
Power
ON/OFF
SIQ Signal IQ
PI Perfusion Index
%HbCO Carbon Monoxide
226
234
236

FIG. 7

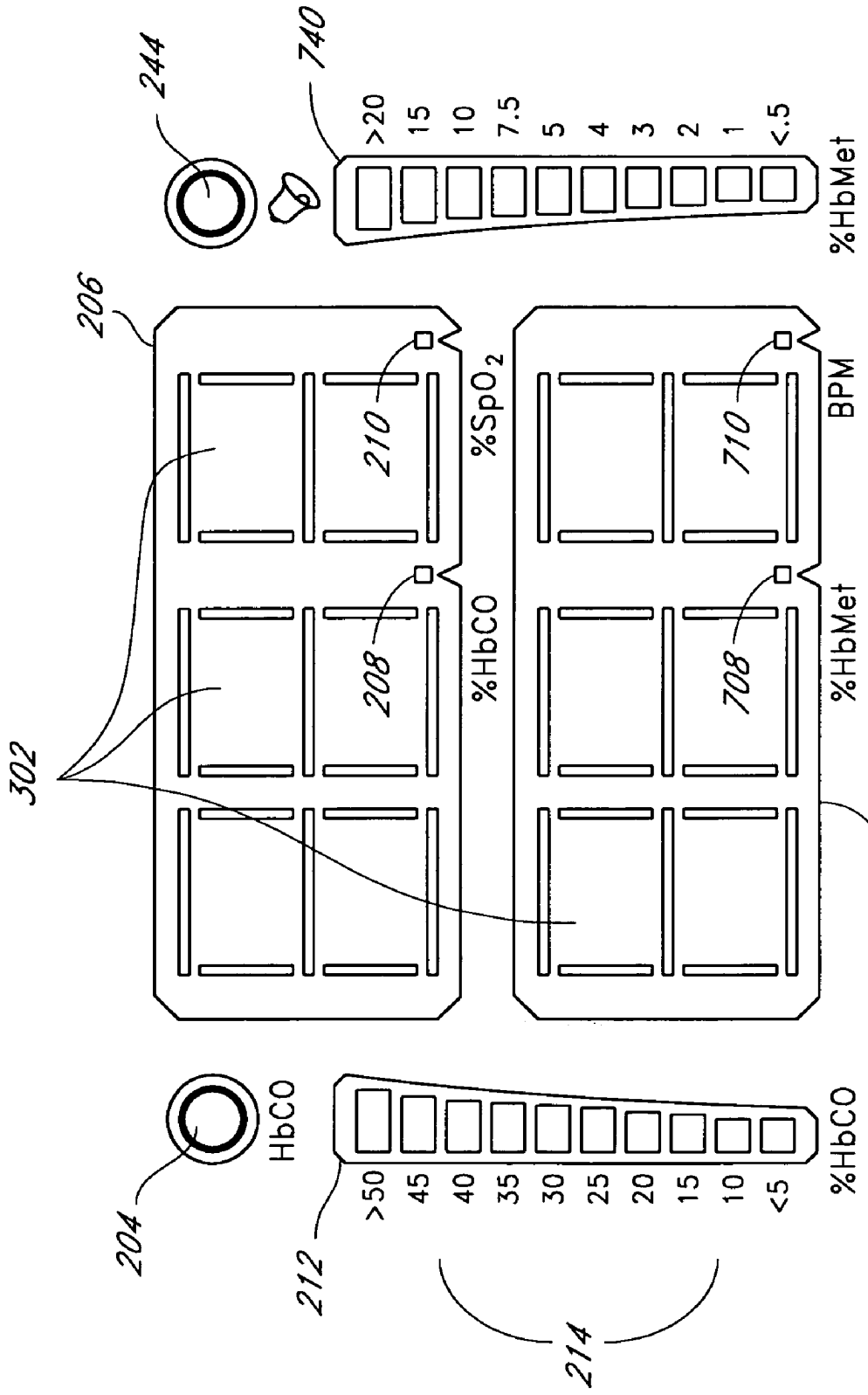

244
740
>20
15
10
7.5
5
4
3
2
1
<.5
%HbMet
206
210
%SpO2
BPM
710
208
%HbCO
708
%HbMet
302
706
HbCO
204
212
>50
45
40
35
30
25
20
15
10
<5
%HbCO
214

FIG. 8

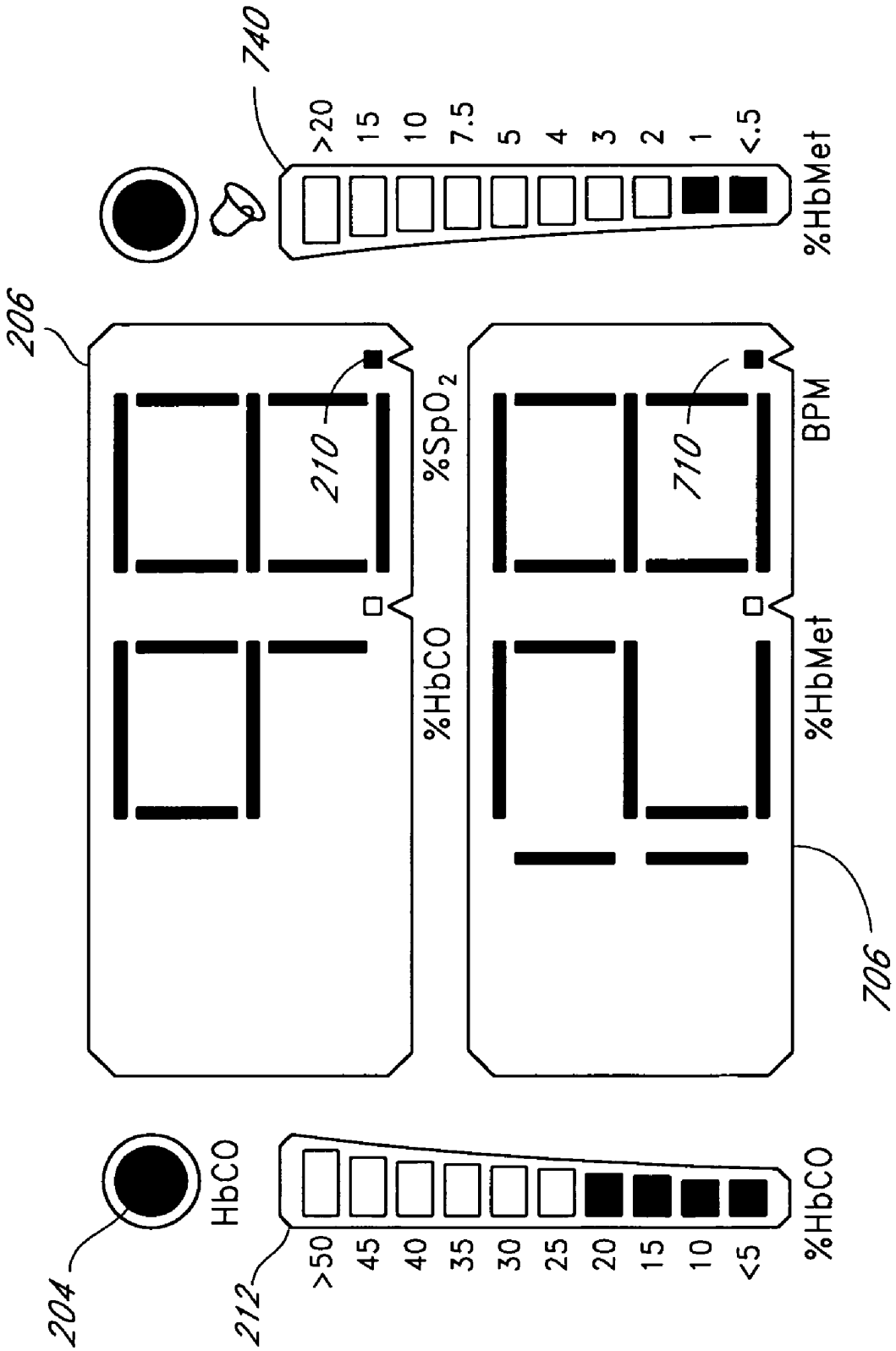

740
>20
15
10
7.5
5
4
3
2
1
<.5
%HbMet
206
210
%SpO2
%HbCO
710
BPM
%HbMet
706
204
HbCO
212
>50
45
40
35
30
25
20
15
10
<5
%HbCO

FIG. 9

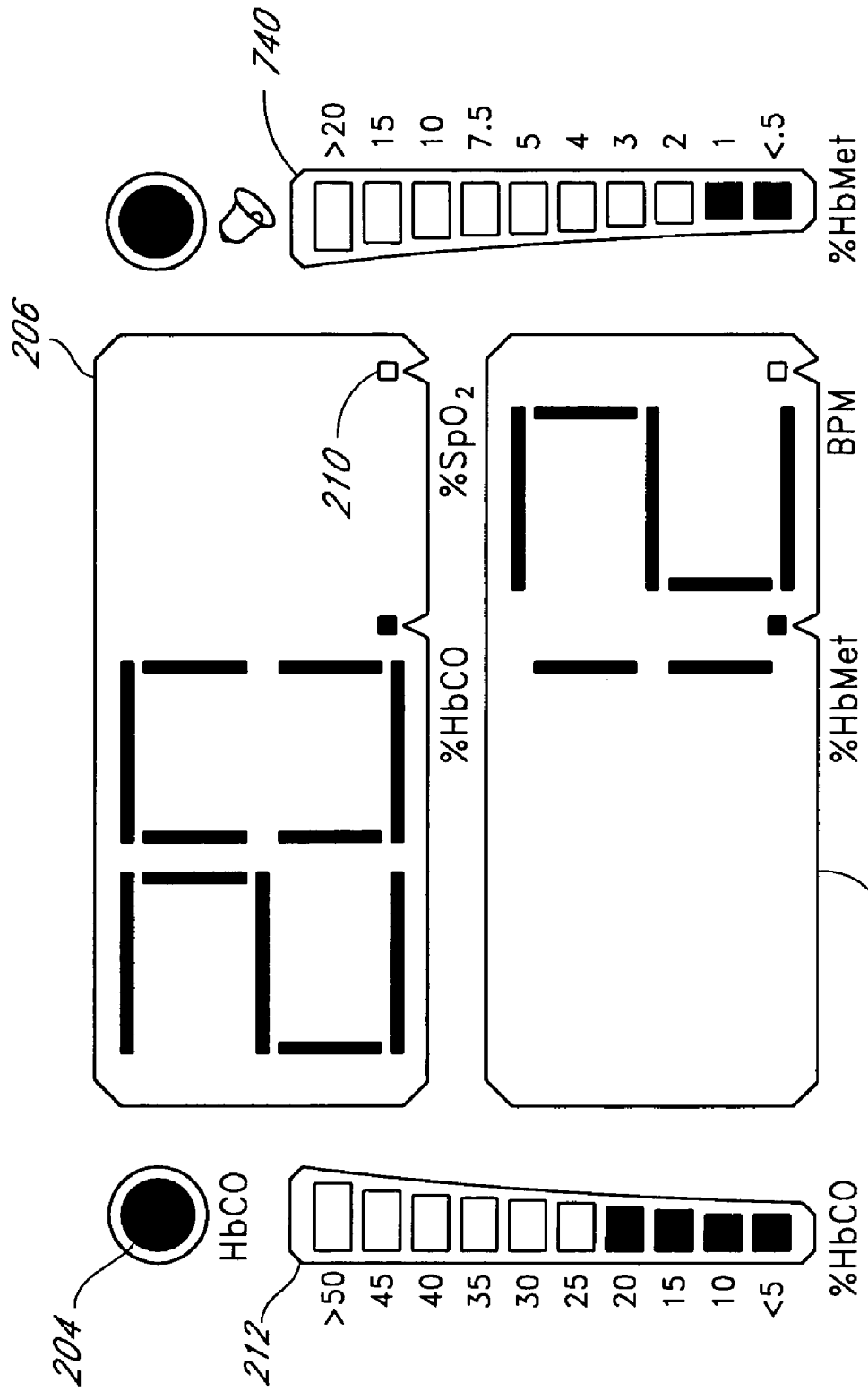

740
>20
15
10
7.5
5
4
3
2
1
<.5
%HbMet
206
210
%SpO2
%HbCO
BPM
%HbMet
706
204
HbCO
212
>50
45
40
35
30
25
20
15
10
<5
%HbCO

FIG. 10

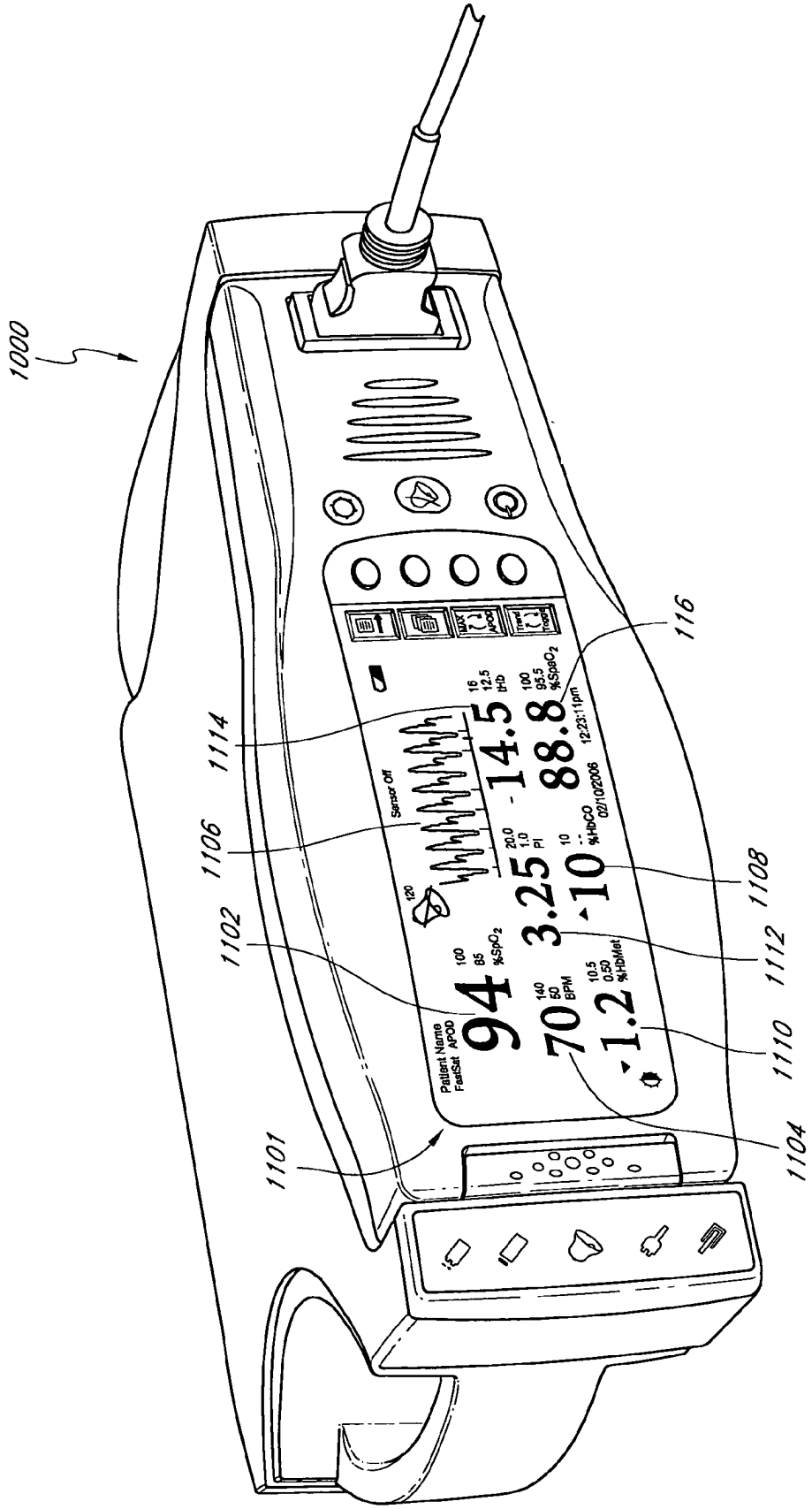

1000
1101
1102
1104
1106
1108
1110
1112
1114
116
Sensor Off
Patient Name
FastSat APOD
94
%SpO2
70
BPM
3.25
PI
-10
%HbCO
-1.2
%HbMet
14.5
Hb
88.8
%SpaO2
12:23:11pm
02/10/2006

FIG. 11A

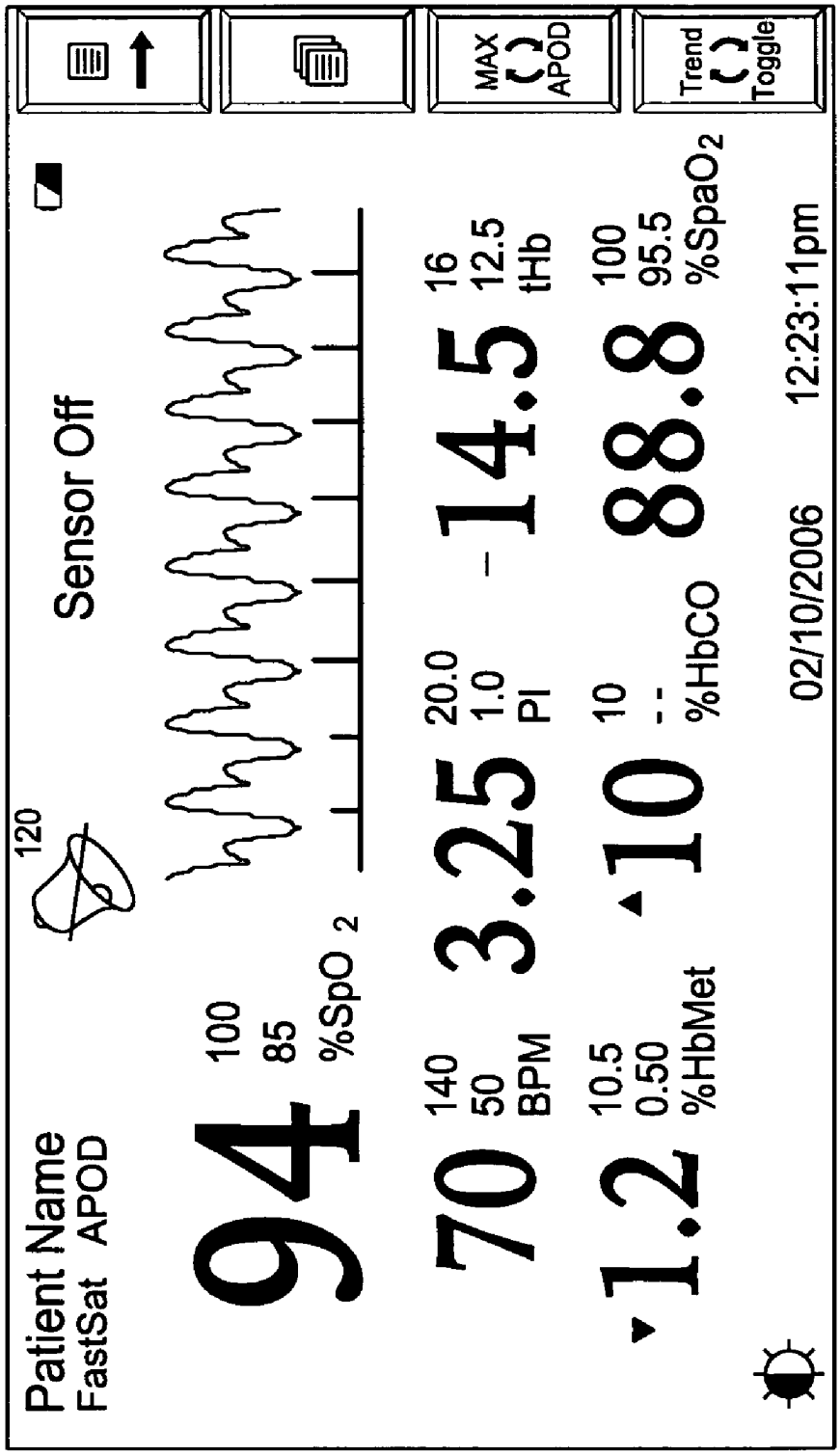

MAX APOD
Trend Toggle
Sensor Off
Patient Name
FastSat APOD
120
94
100
85
%SpO 2
70
140
50
BPM
3.25
20.0
1.0
PI
14.5
16
12.5
tHb
1.2
10.5
0.50
%HbMet
10
10
--
%HbCO
88.8
100
95.5
%SpaO2
02/10/2006
12:23:11pm

FIG. 11B

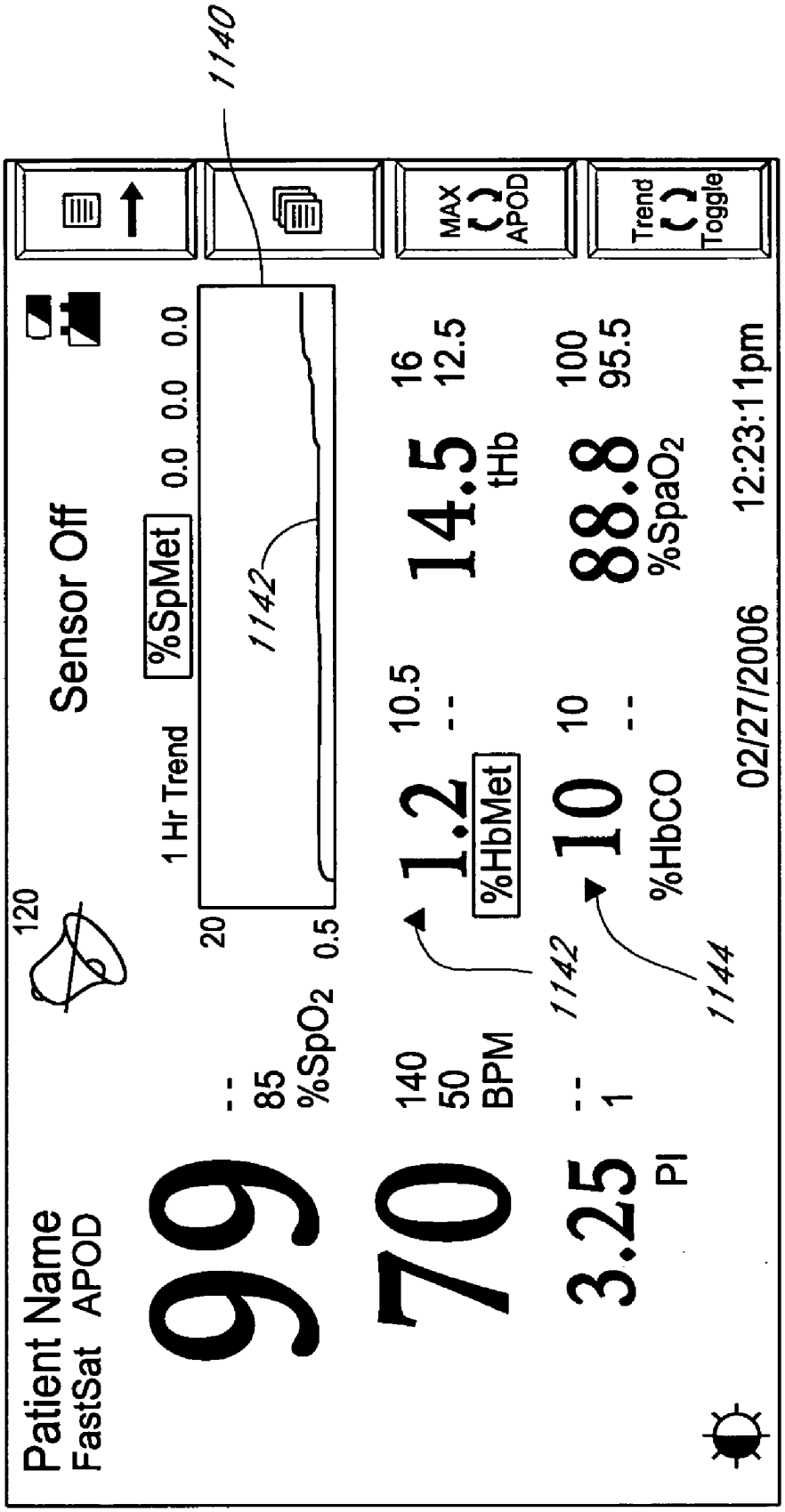

1140
MAX APOD
Trend Toggle
Sensor Off
1 Hr Trend
%SpMet
0.0 0.0 0.0 0.0
1142
20
0.5
120
Patient Name
FastSat APOD
99
-- 85 %SpO2
70
140 50 BPM
3.25
-- 1 PI
1.2
10.5 -- %HbMet
1142
10
10 -- %HbCO
1144
14.5
16 12.5 tHb
88.8
100 95.5 %SpaO2
02/27/2006
12:23:11pm

FIG. 11C

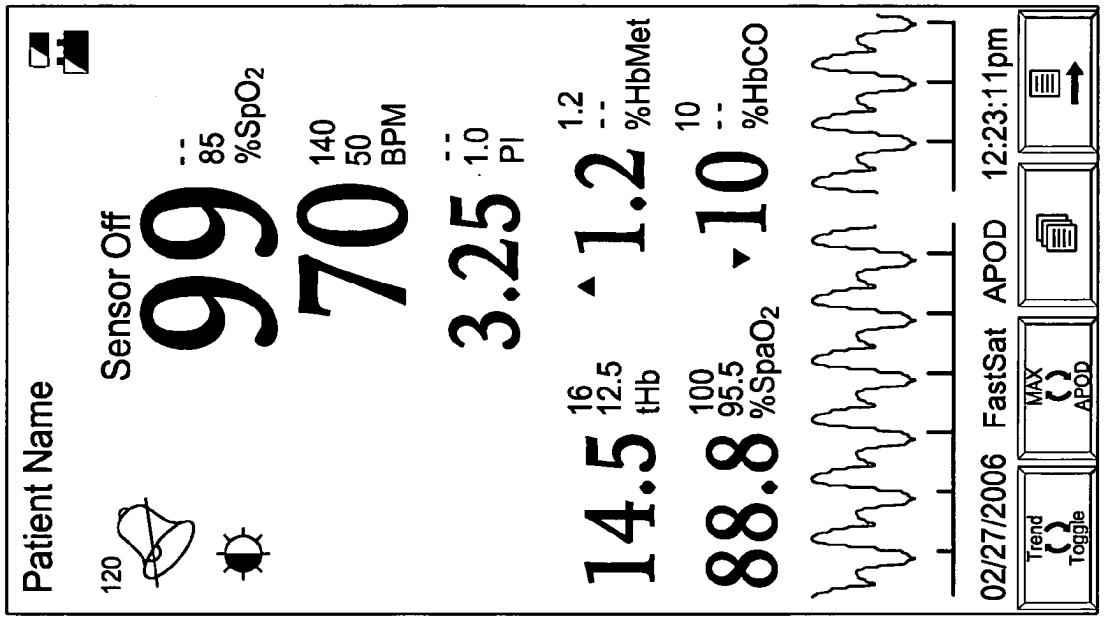

Patient Name
120
Sensor Off
99
85
%SpO2
70
140
50
BPM
3.25
1.0
PI
14.5
16
12.5
tHb
1.2
1.2
%HbMet
88.8
100
95.5
%SpaO2
10
10
%HbCO
02/27/2006
FastSat
APOD
12:23:11pm
Trend
Toggle
MAX
APOD

FIG. 11D

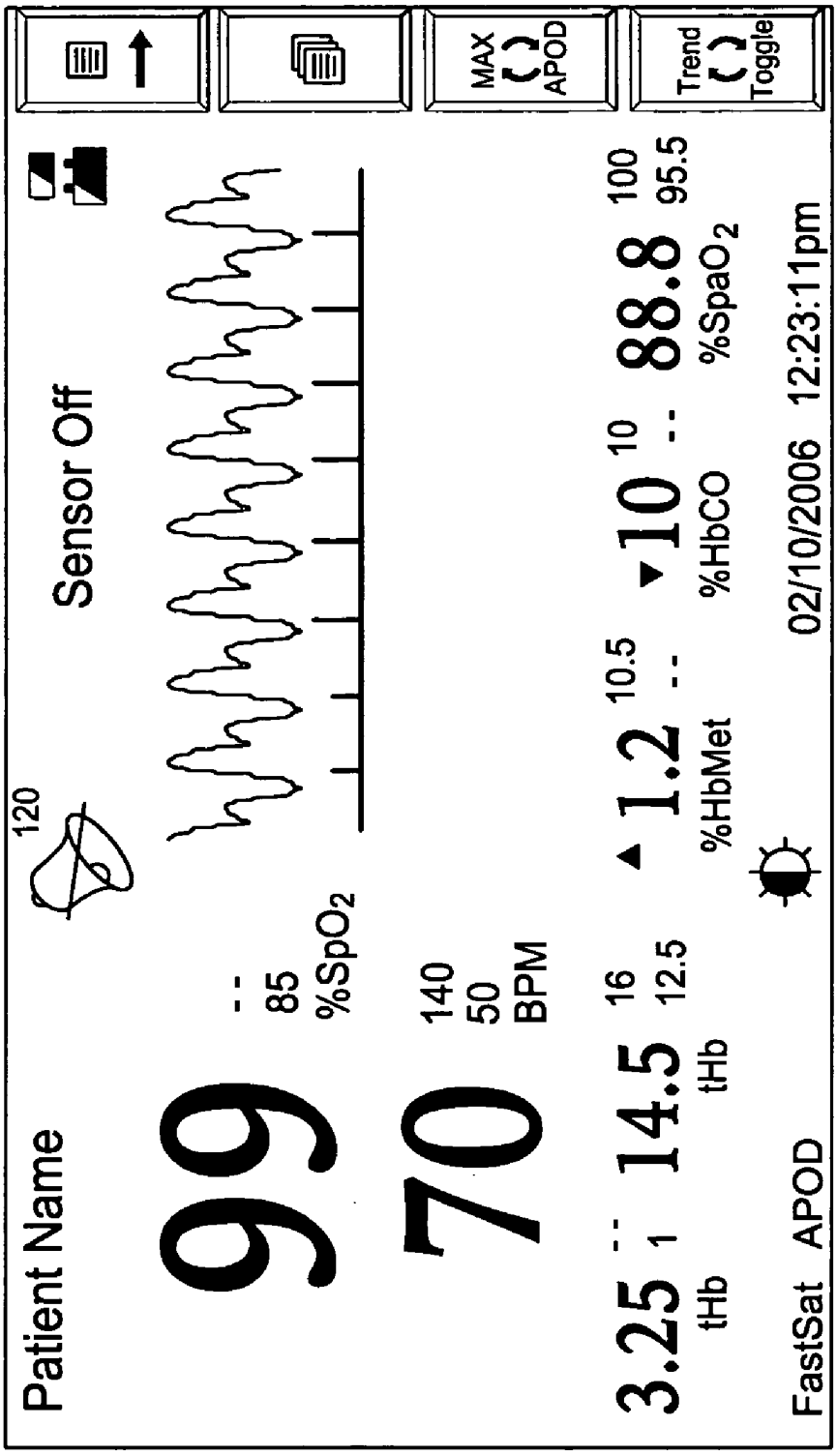

MAX APOD
Trend Toggle
Patient Name
Sensor Off
120
99
%SpO2
85
--
70
140
50
BPM
3.25
tHb
14.5
tHb
16
12.5
1.2
%HbMet
10.5
--
10
%HbCO
10
--
88.8
%SpaO2
100
95.5
FastSat APOD
02/10/2006 12:23:11pm

FIG. 11E

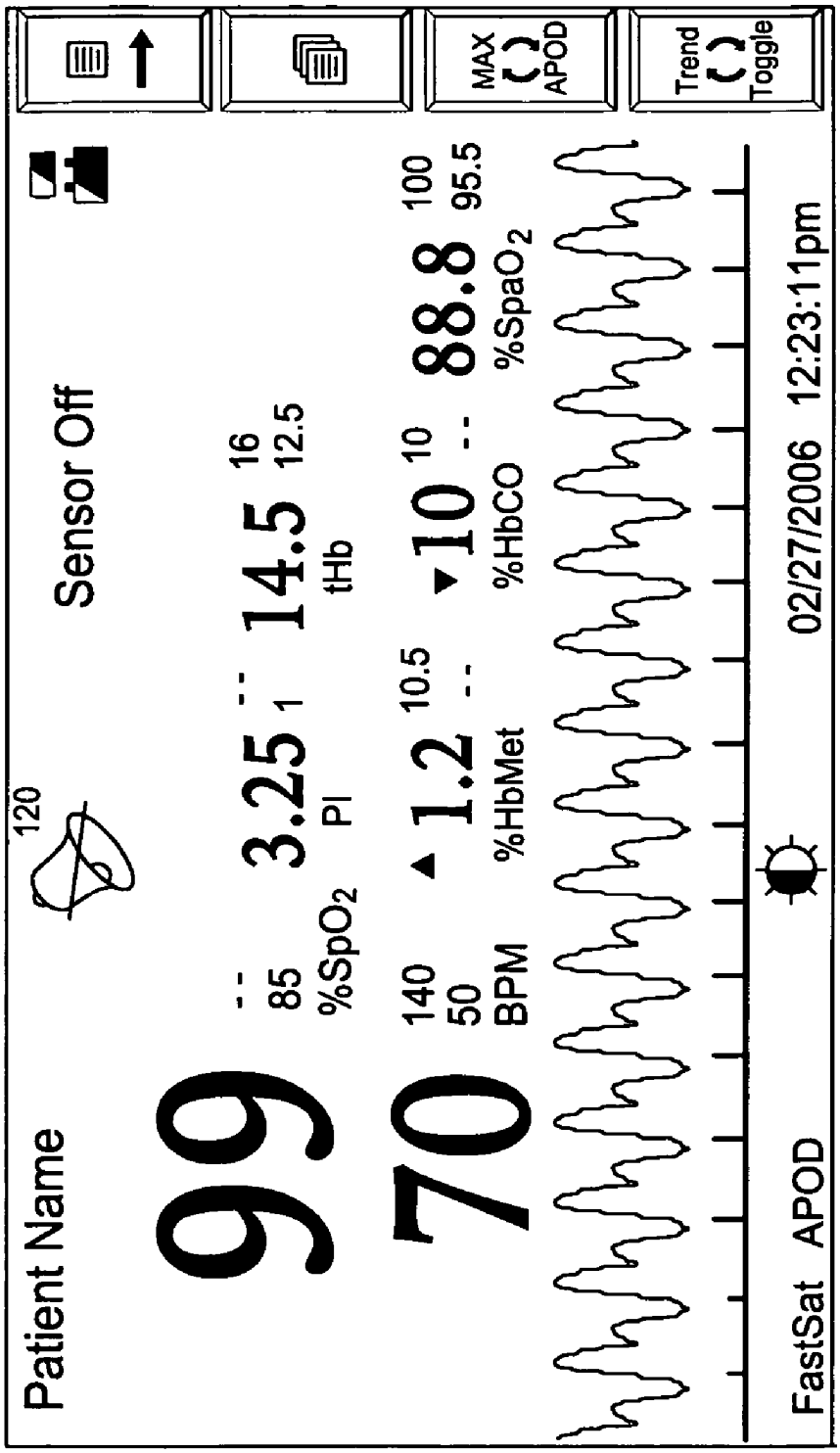

Patient Name
Sensor Off
MAX APOD
Trend Toggle
99
%SpO2
85
--
70
BPM
140
50
3.25
PI
1
--
1.2
%HbMet
10.5
--
14.5
tHb
16
12.5
10
%HbCO
10
--
88.8
%SpaO2
100
95.5
120
FastSat APOD
02/27/2006 12:23:11pm

FIG. 11F

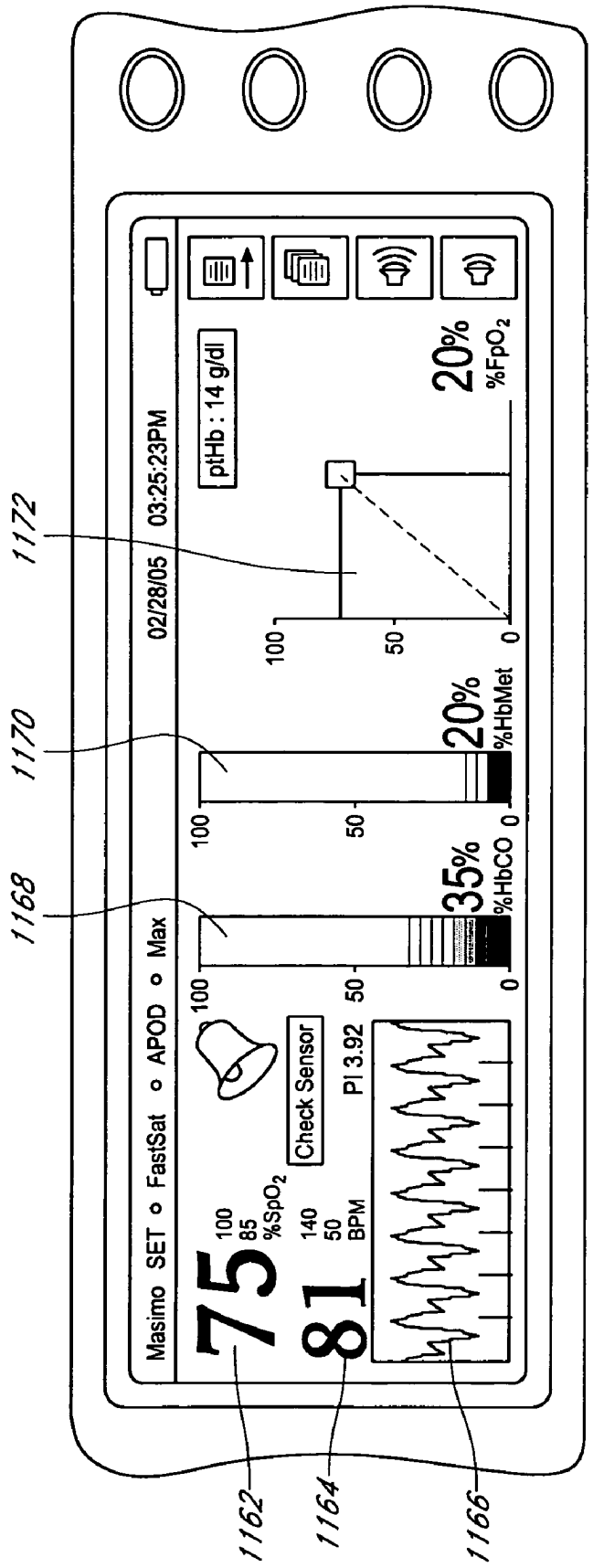

1172
1170
1168
1162
1164
1166
Masimo SET ○ FastSat ○ APOD ○ Max
02/28/05 03:25:23PM
ptHb : 14 g/dl
20% %FpO2
20% %HbMet
35% %HbCO
100
50
0
Check Sensor
PI 3.92
75
81
100
85
%SpO2
140
50
BPM

FIG. 11G

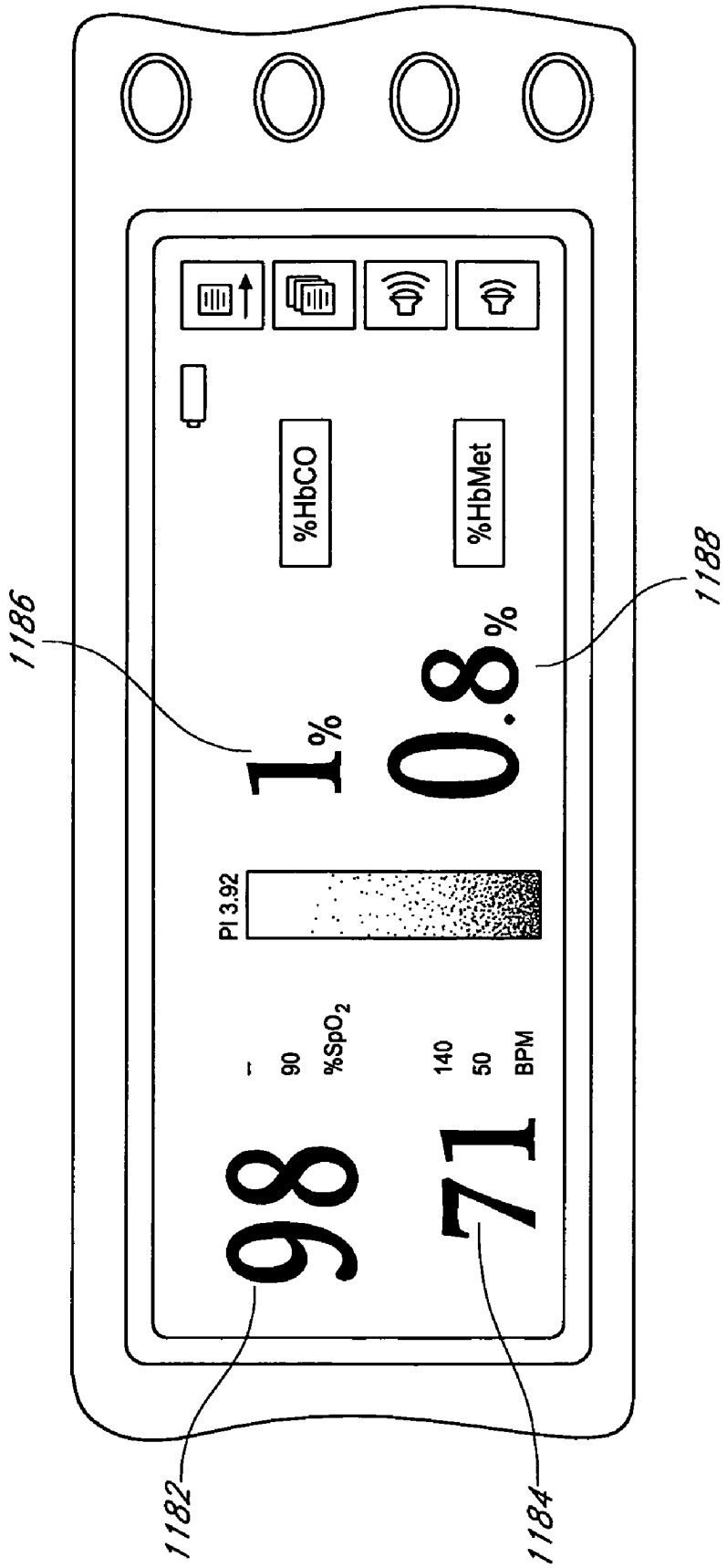

%HbCO
%HbMet
1%
0.8%
PI 3.92
90
%SpO2
140
50
BPM
98
71
1186
1188
1182
1184

FIG. 11H

NONINVASIVE MULTI-PARAMETER PATIENT MONITOR

PRIORITY CLAIM TO RELATED PROVISIONAL APPLICATIONS

The present application claims priority benefit under 35 U.S.C. §119(e) to U.S. Provisional Patent Application Ser. No. 60/657,596, filed Mar. 1, 2005, entitled "Multiple Wavelength Sensor," No. 60/657,281, filed Mar. 1, 2005, entitled "Physiological Parameter Confidence Measure," No. 60/657,268, filed Mar. 1, 2005, entitled "Configurable Physiological Measurement System," and No. 60/657,759, filed Mar. 1, 2005, entitled "Noninvasive Multi-Parameter Patient Monitor." The present application incorporates the foregoing disclosures herein by reference.

INCORPORATION BY REFERENCE OF RELATED UTILITY APPLICATIONS

The present application is related to the following copending U.S. utility applications:

	App. Sr. No.	Filing Date	Title	Atty Dock.
1	11/367,013	Mar. 1, 2006	Multiple Wavelength Sensor Emitters	MLR.002A
2	11/366,995	Mar. 1, 2006	Multiple Wavelength Sensor Equalization	MLR.003A
3	11/366,209	Mar. 1, 2006	Multiple Wavelength Sensor Substrate	MLR.004A
4	11/366,210	Mar. 1, 2006	Multiple Wavelength Sensor Interconnect	MLR.005A
5	11/366,833	Mar. 1, 2006	Multiple Wavelength Sensor Attachment	MLR.006A
6	11/366,997	Mar. 1, 2006	Multiple Wavelength Sensor Drivers	MLR.009A
7	11/367,034	Mar. 1, 2006	Physiological Parameter Confidence Measure	MLR.010A
8	11/367,036	Mar. 1, 2006	Configurable Physiological Measurement System	MLR.011A
9	11/367,014	Mar. 1, 2006	Noninvasive Multi-Parameter Patient Monitor	MLR.013A
10	11/366,208	Mar. 1, 2006	Noninvasive Multi-Parameter Patient Monitor	MLR.014A

The present application incorporates the foregoing disclosures herein by reference.

FIELD OF THE DISCLOSURE

The present disclosure relates to the field of noninvasive patient monitors. More specifically, the disclosure relates to monitors displaying measurements derived using signals from optical sensors.

BACKGROUND

Spectroscopy is a common technique for measuring the concentration of organic and some inorganic constituents of a solution. The theoretical basis of this technique is the Beer-Lambert law, which states that the concentration c_i of an absorbent in solution can be determined by the intensity of light transmitted through the solution, knowing the path-length d_λ, the intensity of the incident light $I_{0,\lambda}$, and the extinction coefficient $\epsilon_{i,\lambda}$ at a particular wavelength λ. In generalized form, the Beer-Lambert law is expressed as:

$$I_\lambda = I_{0,\lambda} e^{-d_\lambda \cdot \mu_{0,\lambda}} \quad (1)$$

$$\mu_{0,\lambda} = \sum_{i=1}^{n} \varepsilon_{i,\lambda} \cdot c_i \quad (2)$$

where $\mu_{0,\lambda}$ is the bulk absorption coefficient and represents the probability of absorption per unit length. The minimum number of discrete wavelengths that are required to solve Equations 1-2 are the number of significant absorbers that are present in the solution.

A practical application of this technique is pulse oximetry, which utilizes a noninvasive sensor to measure oxygen saturation (SpO_2) and pulse rate. In general, the sensor has light emitting diodes (LEDs) that transmit optical radiation of red and infrared wavelengths into a tissue site and a detector that responds to the intensity of the optical radiation after absorption (e.g., by transmission or transreflectance) by pulsatile arterial blood flowing within the tissue site. Based on this response, a processor determines measurements for SpO_2, pulse rate, and can output representative plethysmographic waveforms. Thus, "pulse oximetry" as used herein encompasses its broad ordinary meaning known to one of skill in the art, which includes at least those noninvasive procedures for measuring parameters of circulating blood through spectroscopy. Moreover, "plethysmograph" as used herein (commonly referred to as "photoplethysmograph"), encompasses its broad ordinary meaning known to one of skill in the art, which includes at least data representative of a change in the absorption of particular wavelengths of light as a function of the changes in body tissue resulting from pulsing blood.

Pulse oximeters capable of reading through motion induced noise are available from Masimo Corporation ("Masimo") of Irvine, Calif. Moreover, portable and other oximeters capable of reading through motion induced noise are disclosed in at least U.S. Pat. Nos. 6,770,028, 6,658,276, 6,157,850, 6,002,952, and 5,769,785. Read which are owned by Masimo, and are incorporated by reference herein. Such reading through motion oximeters have gained rapid acceptance in a wide variety of medical applications, including surgical wards, intensive care and neonatal units, general wards, home care, physical training, and virtually all types of monitoring scenarios.

SUMMARY OF THE DISCLOSURE

Despite the success of read through motion oximeter systems, there is a need to provide patient monitors capable of displaying multiple physiological parameters, other than or in addition to SpO_2, plethysmograph waveforms, or pulse rates. For example, in accessing a patient's condition, caregivers often desire knowledge of other blood constituents, including for example, a percent value for arterial carbon monoxide saturation ("HbCO") or a percent value for methemogobin saturation ("HbMet") or the like. For example, in an embodiment, the display advantageously displays one or more of the following: pulse rate, plethysmograph waveform data, perfusion index, values of blood constituents in body tissue, including for example, HbCO, HbMet, total hemoglobin ("Hbt"), arterial oxygen saturation ("SpO_2"), fractional arterial oxygen saturation ("$SpaO_2$"), or the like. In other embodiments, the monitor may advantageously and accurately determine values for one or more of HbO_2, Hb, blood glucose,

water, the presence or absence of therapeutic drugs (aspirin, Dapson, nitrates, or the like) or abusive/recreational drugs (methamphetamine, alcohol, steroids, or the like), concentrations of carbon dioxide ("CO_2") or oxygen ("O"), ph levels, bilirubin, perfusion quality, signal quality or the like. Accordingly, the present disclosure includes a multi-parameter patient monitor capable of determining one or more of the foregoing parameters, other than or in addition to, SpO_2, plethysmograph waveforms, or perfusion quality index.

In an embodiment, the display of a noninvasive multi-parameter patient monitor advantageously includes a plurality of display modes enabling more parameter data to be displayed than the available physical display area or real estate. In an embodiment, a user may cycle different parameter values through an area of the display common to both parameters even when one parameter is shifted, through, for example, actuation of a user input key. The patient monitor may also display different parameters as color-coded. For example, when the following measured parameters are within "normal" ranges, SpO_2 may be displayed red, pulse rate (BPM) may be displayed green, HbCO may be displayed orange, HbMet may be displayed blue, or the like. In an embodiment, measured values of SpO_2 may be displayed in white, BPM may be displayed in yellow green or aquamarine, PI™ may be displayed in violet, Hbt may be displayed in grass green, HbMet may be displayed in blue or light blue, HbCO may be displayed in orange, and $SpaO_2$ may be displayed in electric blue.

Moreover, parameter trend data may also be displayed using the same or similar color coding, especially when multiple trends are displayed on one or more display graphs. In addition, more coarse or gross parameter indications may be displayed for quick reference to indicate to a caregiver whether any of a variety of monitored parameters, such as, for example, SpO_2, HbCO or HbMet is within acceptable ranges. The monitor may advantageously include additional display information, such as, for example, parametric displays where one parameter is displayed as a function of another, three dimensional displays (for example, extending a parametric display along time or an additional parameter), directional indicators predicting where a parameter is likely heading or reporting a general direction a parameters has been trending, or the like.

In addition to the foregoing, caregivers often desire to more closely monitor parameters that are close to, approaching, or beyond normal safe thresholds. In an embodiment, the patient monitor provides an indication that the caregiver should change display modes to view more critical monitored parameters. In alternative embodiments, the patient monitor automatically changes display modes to show parameters moving closer to or beyond normal thresholds.

In an embodiment, the patient monitor includes an audible or visual indication of a type of sensor communicating with the monitor. For example, the monitor may determine how many wavelengths a particular attached sensor will emit through communication with memory devices associated with the attached sensor or cable.

Additional embodiments include audio or visual alarms for each of multiple monitored parameters, combinations of parameters, an indication of perfusion in the tissue of the measurement site, an indication of the confidence the signal processing has in its output measurements, or the like.

For purposes of summarization, certain aspects, advantages and novel features are described herein. Of course, it is to be understood that not necessarily all such aspects, advantages or features need to be present in any particular embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings and the associated descriptions are provided to illustrate embodiments of the disclosure and not to limit the scope of the claims.

FIG. **1** illustrates a block diagram of an exemplary embodiment of a patient monitoring system including a sensor and a multi-parameter patient monitor.

FIG. **2** illustrates a top elevation view of an exemplary handheld noninvasive multi-parameter patient monitor capable of displaying at least HbCO, such as, for example, the patient monitor of FIG. **1**.

FIG. **3** illustrates an exemplary display of the patient monitor of FIG. **2**.

FIG. **4** illustrates the display of FIG. **3** showing measured values of SpO_2, BPM, perfusion, and type of sensor according to an exemplary embodiment of the patient monitor of FIG. **1**.

FIG. **5** illustrates the display of FIG. **3** showing measured values of HbCO, perfusion, and type of sensor according to an exemplary embodiment of the patient monitor of FIG. **1**.

FIG. **6** illustrates the display of FIG. **3** showing measured values of SpO_2, HbCO, BPM, perfusion, and type of sensor, according to an exemplary embodiment of the patient monitor of FIG. **1**.

FIG. **7** illustrates a top elevation view of an exemplary handheld noninvasive multi-parameter patient monitor capable of displaying at least HbCO and HbMet, such as, for example, the patient monitor of FIG. **1**.

FIG. **8** illustrates an exemplary display of the patient monitor of FIG. **7**.

FIG. **9** illustrates the display of FIG. **8** showing measured values of SpO_2, BPM, HbCO, HbMet, and type of sensor according to an exemplary embodiment of the patient monitor of FIG. **1**.

FIG. **10** illustrates the display of FIG. **8** showing measured values of HbCO, HbMet, and type of sensor according to an exemplary embodiment of the patient monitor of FIG. **1**.

FIG. **11**A illustrates a perspective view of an exemplary noninvasive multi-parameter patient monitor such as, for example, the patient monitor of FIG. **1**.

FIGS. **11**B-**11**H illustrate display screens of the patient monitor of FIG. **11**A.

DETAILED DESCRIPTION OF PREFERRED AND ALTERNATIVE EMBODIMENTS

Embodiments of the present disclosure include a portable or other multi-parameter patient monitor capable of determining multiple physiological parameters from one or more signals output from one or more light sensitive detectors capable of detecting light attenuated by body tissue carrying pulsing blood. For example, in an embodiment, the monitor advantageously and accurately determines a wide variety of physiological parameters or other calculations as discussed above.

In an embodiment, the display of patient monitor advantageously includes a plurality of display modes enabling more parameter data to be displayed than the available physical display real estate. For example, the patient monitor may include one or more user input keys capable of toggling through measurement data. In an embodiment, the displays include mode indicators providing caregivers easily identifiable visual queues, such as LED's, text, icons, or other indicia providing readily identifiable queues as to which parameter is being displayed. In an embodiment, the display may shift, may be parameter color-coded, or the like to further ensure

quick comprehension of which measured parameter is the displayed parameter. For example, in an embodiment, the monitor displays SpO_2 in white, pulse rate (BPM) in green, HbCO in orange, and HbMet in blue when the respective measured parameter is within a "normal" range.

In an embodiment, the patient monitor provides an indication that the caregiver should change display modes to view more critical or time sensitive measured parameters, specific caregiver selected parameters, or the like. For example, the patient monitor may advantageously sound audio or visual alarms that alert the caregiver to particular one or more of worsening parameters, parameters changing in a predetermined pattern or rate, parameters stabilizing below user defined or safe thresholds, caregiver selected parameters, or the like. The monitor may also use alerts that provide audio or visual indications of the severity of the condition, severity of the change, or the like. In alternative embodiments, the patient monitor may automatically change display modes when a particular parameter crosses one or more thresholds. For example, a patient monitor may be displaying a first parameter, such as a plethysmograph, and upon determining measurements indicating that HBMet is trending toward an alarm condition, the monitor may automatically switch from displaying the first parameter to the alarming parameter, or in this case, a trend of the alarming parameter.

In an embodiment, a switch is provided to allow a user to switch displays to view an alarming measurement. In an embodiment, during an alarm condition, a parameter display may switch to a trend graph in the same or different color, line weight, flash, flash rate, intensity, size, or the like.

The patient monitor may also include one or more displays capable of displaying trend data for any one or more of the monitored or derived patient parameters. For example, the trend data may be displayed in graph form, may include multiple trend lines, each representing a different monitored or derived patient parameter. Moreover, each trend line may be color-coded to facilitate quick comprehension of which trend line represents which measured parameter. However, an artisan will recognize from the disclosure herein a large number of identification techniques including color-coding, identifying text, or the like. Additionally, user input may toggle displayed trend data, may select which parameters to display simultaneously, or the like.

In an embodiment, the patient monitor includes an audible or visual indication of a type of sensor communicating with the monitor. For example, the patient monitor may provide a particular audio or visual indication, such as a beep, LED activation, graphic activation, text messages, voice messages, or the like, to indicate communication with or connection to an approved sensor, patient cable, combination, or the like. In an embodiment, the indication may change based on the manufacturer, type of sensor recognized or not recognized, type of patient, type of physiological parameters measurable with the attached sensor, or the like. Additional embodiments include an indication of perfusion in the tissue of the measurement site and an indication of the confidence the signal processing has in its output measurements or input signal quality.

To facilitate an understanding of the disclosure, the remainder of the description references exemplary embodiments illustrated in the drawings. Moreover, in this application, reference is made to many blood parameters. Some references that have common shorthand designations are referenced through such shorthand designations. For example, as used herein, HbCO designates carboxyhemoglobin, HbMet designates methemoglobin, and Hbt designates total hemoglobin. Other shorthand designations such as COHb, MetHb, and tHb are also common in the art for these same constituents. These constituents are generally reported herein in terms of a percentage, often referred to as saturation, relative concentration or fractional saturation. Total hemoglobin is generally reported as a concentration in g/dL. The use of the particular shorthand designators presented in this application does not restrict the term to any particular manner in which the designated constituent is reported.

FIG. **1** illustrates a block diagram of an exemplary embodiment of a patient monitoring system **100**. As shown in FIG. **1**, the system **100** includes a patient monitor **102** comprising a processing board **104** and a host instrument **108**. The processing board **104** communicates with a sensor **106** to receive one or more intensity signal(s) indicative of one or more parameters of tissue of a patient. The processing board **104** also communicates with a host instrument **108** to display determined values calculated using the one or more intensity signals. According to an embodiment, the board **104** comprises processing circuitry arranged on one or more printed circuit boards capable of installation into the monitor **102**, or capable of being distributed as some or all of one or more OEM components for a wide variety of host instruments monitoring a wide variety of patient information. In an embodiment, the processing board **102** comprises a sensor interface **110**, a digital signal processor and signal extractor ("DSP" or "processor") **112**, and an instrument manager **114**. In general, the sensor interface **110** converts digital control signals into analog drive signals capable of driving sensor emitters, and converts composite analog intensity signal(s) from light sensitive detectors into digital data.

In an embodiment, the sensor interface **110** manages communication with external computing devices. For example, in an embodiment, a multipurpose sensor port (or input/output port) is capable of connecting to the sensor **106** or alternatively connecting to a computing device, such as a personal computer, a PDA, additional monitoring equipment or networks, or the like. When connected to the computing device, the processing board **104** may upload various stored data for, for example, off-line analysis and diagnosis. The stored data may comprise trend data for any one or more of the measured parameter data, plethysmograph waveform data acoustic sound waveform, or the like. Moreover, the processing board **104** may advantageously download from the computing device various upgrades or executable programs, may perform diagnosis on the hardware or software of the monitor **102**. In addition, the processing board **104** may advantageously be used to view and examine patient data, including raw data, at or away from a monitoring site, through data uploads/downloads, or network connections, combinations, or the like, such as for customer support purposes including software maintenance, customer technical support, and the like. Upgradable sensor ports are disclosed in copending U.S. application Ser. No. 10/898,680, filed on Jul. 23, 2004, titled "Multipurpose Sensor Port," incorporated by reference herein.

As shown in FIG. **1**, the digital data is output to the DSP **112**. According to an embodiment, the DSP **112** comprises a processing device based on the Super Harvard ARChitecture ("SHARC"), such as those commercially available from Analog Devices. However, a skilled artisan will recognize from the disclosure herein that the DSP **112** can comprise a wide variety of data and/or signal processors capable of executing programs for determining physiological parameters from input data. In particular, the DSP **112** includes program instructions capable of receiving multiple channels of data related to one or more intensity signals representative of the absorption (from transmissive or reflective sensor systems) of

a plurality of wavelengths of emitted light by body tissue. In an embodiment, the DSP **112** accepts data related to the absorption of eight (8) wavelengths of light, although an artisan will recognize from the disclosure herein that the data can be related to the absorption of two (2) to sixteen (16) or more wavelengths.

FIG. **1** also shows the processing board **104** including the instrument manager **114**. According to an embodiment, the instrument manager **114** may comprise one or more microcontrollers controlling system management, including, for example, communications of calculated parameter data and the like to the host instrument **108**. The instrument manager **114** may also act as a watchdog circuit by, for example, monitoring the activity of the DSP **112** and resetting it when appropriate.

The sensor **106** may comprise a reusable clip-type sensor, a disposable adhesive-type sensor, a combination sensor having reusable and disposable components, or the like. Moreover, an artisan will recognize from the disclosure herein that the sensor **106** can also comprise mechanical structures, adhesive or other tape structures, Velcro wraps or combination structures specialized for the type of patient, type of monitoring, type of monitor, or the like. In an embodiment, the sensor **106** provides data to the board **104** and vice versa through, for example, a patient cable. An artisan will also recognize from the disclosure herein that such communication can be wireless, over public or private networks or computing systems or devices, or the like.

As shown in FIG. **1**, the sensor **106** includes a plurality of emitters **116** irradiating the body tissue **118** with differing wavelengths of light, and one or more detectors **120** capable of detecting the light after attenuation by the tissue **118**. In an embodiment, the emitters **116** comprise a matrix of eight (8) emission devices mounted on a flexible substrate, the emission devices being capable of emitting eight (8) differing wavelengths of light. In other embodiments, the emitters **116** may comprise twelve (12) or sixteen (16) emitters, although other numbers of emitters are contemplated, including two (2) or more emitters. As shown in FIG. **1**, the sensor **106** may include other electrical components such as, for example, a memory device **122** comprising an EPROM, EEPROM, ROM, RAM, microcontroller, combinations of the same, or the like. In an embodiment, other sensor components may include a temperature determination device **123** or other mechanisms for, for example, determining real-time emission wavelengths of the emitters **116**.

The memory **122** may advantageous store some or all of a wide variety data and information, including, for example, information on the type or operation of the sensor **106**; type or identification of sensor buyer or distributor or groups of buyer or distributors, sensor manufacturer information, sensor characteristics including the number of emitting devices, the number of emission wavelengths, data relating to emission centroids, data relating to a change in emission characteristics based on varying temperature, history of the sensor temperature, current, or voltage, emitter specifications, emitter drive requirements, demodulation data, calculation mode data, the parameters for which the sensor is capable of supplying sufficient measurement data (e.g., HpCO, HpMet, HbT, or the like), calibration or parameter coefficient data, software such as scripts, executable code, or the like, sensor electronic elements, whether the sensor is a disposable, reusable, multisite, partially reusable, partially disposable sensor, whether it is an adhesive or non-adhesive sensor, whether the sensor is a reflectance, transmittance, or transreflectance sensor, whether the sensor is a finger, hand, foot, forehead, or ear sensor, whether the sensor is a stereo sensor or a two-headed sensor, sensor life data indicating whether some or all sensor components have expired and should be replaced, encryption information, keys, indexes to keys or hash functions, or the like, monitor or algorithm upgrade instructions or data, some or all of parameter equations, information about the patient, age, sex, medications, and other information that may be useful for the accuracy or alarm settings and sensitivities, trend history, alarm history, or the like. In an embodiment, the monitor may advantageously store data on the memory device, including, for example, measured trending data for any number of parameters for any number of patients, or the like, sensor use or expiration calculations, sensor history, or the like.

FIG. **1** also shows the patient monitor **102** including the host instrument **108**. In an embodiment, the host instrument **108** communicates with the board **104** to receive signals indicative of the physiological parameter information calculated by the DSP **112**. The host instrument **108** preferably includes one or more display devices **124** capable of displaying indicia representative of the calculated physiological parameters of the tissue **118** at the measurement site. In an embodiment, the host instrument **108** may advantageously comprise a handheld housing capable of displaying one or more of a pulse rate, plethysmograph data, perfusion quality such as a perfusion quality index ("PI™"), signal or measurement quality ("SQ"), values of blood constituents in body tissue, including for example, SpO_2, HbCO, HbMet, Hbt, or the like. In other embodiments, the host instrument **108** is capable of displaying values for one or more of Hbt, Hb, blood glucose, bilirubin, or the like. The host instrument **108** may be capable of storing or displaying historical or trending data related to one or more of the measured values, combinations of the measured values, plethysmograph data, or the like. The host instrument **108** also includes an audio indicator **126** and user input device **128**, such as, for example, a keypad, touch screen, pointing device, voice recognition device, or the like.

In still additional embodiments, the host instrument **108** includes audio or visual alarms that alert caregivers that one or more physiological parameters are falling below predetermined safe thresholds. The host instrument **108** may include indications of the confidence a caregiver should have in the displayed data. In a further embodiment, the host instrument **108** may advantageously include circuitry capable of determining the expiration or overuse of components of the sensor **106**, including, for example, reusable elements, disposable elements, or combinations of the same.

Although described in terms of certain embodiments, other embodiments or combination of embodiments will be apparent to those of ordinary skill in the art from the disclosure herein. For example, the monitor **102** may comprise one or more monitoring systems monitoring parameters, such as, for example, vital signs, blood pressure, ECG or EKG, respiration, glucose, bilirubin, or the like. Such systems may combine other information with intensity-derived information to influence diagnosis or device operation. Moreover, the monitor **102** may advantageously include an audio system, preferably comprising a high quality audio processor and high quality speakers to provide for voiced alarms, messaging, or the like. In an embodiment, the monitor **102** may advantageously include an audio out jack, conventional audio jacks, headphone jacks, or the like, such that any of the display information disclosed herein may be audiblized for a listener. For example, the monitor **102** may include an audible transducer input (such as a microphone, piezoelectric sensor, or the like) for collecting one or more of heart sounds, lung sounds, trachea sounds, or other body sounds and such

sounds may be reproduced through the audio system and output from the monitor **102**. Also, wired or wireless communications (such as Bluetooth or WiFi, including IEEE 801.11a, b, or g), mobile communications, combinations of the same, or the like, may be used to transmit the audio output to other audio transducers separate from the monitor **102**.

For example, patterns or changes in the continuous noninvasive monitoring of intensity-derived information may cause the activation of other vital sign measurement devices, such as, for example, blood pressure cuffs.

FIG. **2** illustrates a perspective view of an exemplary handheld noninvasive multi-parameter patient monitor **200**, such as, for example, the patient monitor **102** of FIG. **2**. Patient monitors **200** exhibiting combinations of many of the features described herein are advantageously commercially available from Masimo under the brand name "Rad 57c." As shown in FIG. **1**, the monitor **200** includes a patient cable connector **202** capable of mechanical mating with a patient cable to establish communication between the board **104** and the sensor **106**. In an embodiment, the connector **202** comprises a multipurpose cable connector such as that disclosed in the incorporated U.S. application Ser. No. 10/898,680, titled "Multipurpose Sensor Port," disclosing communication between the board **104** and an external computing device.

The monitor **200** also comprises a HbCO indicator **204** advantageously providing a visual queue that a HbCO capable sensor is properly connected through the connector **202**. For example, the HbCO indicator **204** may advantageously activate when a sensor is connected that communicates sufficient information to determine HbCO, such as, for example, a sensor capable of emitting sufficient different wavelengths of light, a sensor storing sufficient data on the memory **122**, a sensor having appropriate encryption data or key, combinations of the same, or the like. For example, in an embodiment, the processor **112** may receive information from a memory **122** indicating a number of available LED wavelengths for the attached sensor. Based on the number of wavelengths, or other information stored on the memory **122**, the processor **112** may determine whether an HbCO-ready sensor has been attached to the monitor **200**. An artisan will also recognize from the disclosure herein that the HbCO indicator **204** may advantageously comprise a HbMet indicator, Hbt indicator, or the like, which activates to a predetermined color associated with a parameter, or any color, or deactivates the same, to convey a type of attached sensor. Moreover, the artisan will recognize from the disclosure herein other parameters that may use other sensor components and the monitor **200** may include indicators capable of indicating communication with those types of sensors.

In an embodiment, the monitor **200** may also audibly indicate the type of sensor connected. For example, the monitor **200** may emit predetermined number or frequency of beeps associated with recognition of a particular sensor, a particular manufacturer, failure to recognize the sensor, or the like. Moreover, the sensor type may be indicative of the componentry, such as, for example, whether the sensor produces sufficient data for the determination of HbCO, HbMet, Hbt and SpO_2, SpO_2 only, SpO_2 and HbMet, any combination of the foregoing or other parameters, or the like. Additionally, the sensor type may be indicative of specific sensors designed for a type of patient, type of patient tissue, or the like. In other embodiments, the monitor **200** may announce the type of connector through speaker **236**.

An artisan will also recognize from the disclosure herein that other mechanical (such as keys), electrical, or combination devices may inform the monitor **200** of the type of attached sensor. In an embodiment, the processor **112** also may select to drive less emitters that are currently available, such as, for example, in the presence of low noise and when power consumption is an issue.

The monitor **200** also comprises a multi-mode display **206** capable of displaying, for example, measurements of SpO_2 and HbCO (or alternatively, HbMet). In an embodiment, the display **206** has insufficient space or display real estate to display the many parameters capable of being measured by the monitor **200**. Thus, the multi-mode display **206** may advantageously cycle through two or more measured parameters in an area common to both parameters even when shifted. In such embodiments, the monitor **200** may also advantageously include parameter indicators **208**, **210**, providing additional visual queues as to which parameter is currently displayed. In an embodiment, the display may also cycle colors, flash rates, or other audio or visual queues providing readily identifiable information as to which measured parameter is displayed. For example, when the multi-mode display **206** displays measured values of SpO_2 that are normal, the numbers may advantageously appear in green, while normal measured values of HbCO may advantageously appear in orange, and normal measured values of HbMet may appear in blue. Moreover, in an embodiment, the display **206** flashes at a predefined rate when searching for saturation and at another predefined rate when a signal quality is below a predetermined threshold.

The monitor **200** also comprises a HbCO bar **212** where in an embodiment a plurality of LED's activate from a bottom toward a top such that the bar "fills" to a level proportional to the measured value. For example, the bar **212** is lowest when the dangers from carbon monoxide poisoning are the least, and highest when the dangers are the greatest. The bar **212** includes indicia **214** that provide an indication of the severity of carbon monoxide saturation in a patient's blood. As shown in FIG. **2**, the bar **212** and the indicia **214** continuously indicate the concentration of HbCO in about 5% increments. The indicia **214** indicate a measurement of HbCO saturation percentage between about 0 and about 50% with a granularity of about 5%. However, an artisan will also recognize from the disclosure herein a wide variety of ranges and granularities could be used, the indicia **214** could be electronically displayed in order to straightforwardly increase or decrease resolution, or the like. For example, HbCO may advantageously be displayed with greater resolution than ± about %5 in a lower portion of the scale. For example, an HbCO bar may advantageously include a scale of about <3%, about 6%, about 9%, about 12%, about 15%, about 20%, about 25%, about 30%, about 35%, and about >40%.

As is known in the art, carbon monoxide in the blood can lead to serious medical issues. For example and depending upon the particular physiology of a patient, about 10% carbon monoxide saturation can lead to headaches, about 20% can lead to throbbing headaches, or dyspnea on exertion, about 30% can lead to impaired judgment, nausea, dizziness and/or vomiting, visual disturbance, or fatigue, about 40% can lead to confusion and syncope, and about 50% and above can lead to comas, seizures, respiratory failure and even death.

In an embodiment, the bar **212** is the same or similar color as the multi-mode display **206** when displaying HbCO. In other embodiments, the bar **212** is lowest and green when the dangers from carbon monoxide poisoning are the least, and highest and red when the dangers are the greatest. In an embodiment, as HbCO increases, the entire bar **212** may advantageously change color, such as, for example, from green to red, to provide a clear indication of deepening severity of the condition. In other embodiments, the bar **212** may advantageously blink or flash, an audio alarm may beep or

provide a continuation or rise in pitch or volume, or the like to alert a caregiver of deepening severity. Moreover, straightforward to complex alarm rules may be implemented to reduce false alarms based on, for example, knowledge of the physiological limitations on the rate of change in HbCO or the like.

Additionally, the monitor **200** may be capable of storing and outputting historical parameter data, display trend traces or data, or the like. Although the foregoing bar **212** has been described in terms of certain preferred embodiments, other embodiments will be apparent to those of ordinary skill in the art from the disclosure herein.

FIG. **2** also shows the monitor **200** including a pulse display **216** displaying measured pulse rate in beats per minute ("BPM"). In an embodiment, the display **212** flashes when searching for a pulse. The pulse display **216** advantageously displays measured pulse rates from about zero (0) to about two hundred and forty (240) BPM. Moreover, when the measured pulse rates are considered normal, the pulse display **216** is advantageously green. Similar to other displays associated with the monitor **200**, the pulse display **216** may employ a variety of color changes, audio alarms, or combinations of the same to indicate measured BPM below predetermined safe thresholds. In an embodiment, the pulse rate display **216** displays the measured pulse rate during the display of SpO_2 and displays message data during the display of other parameters. For example, during the display of HbCO, the display **216** may advantageously display the term "CO." In an embodiment, the display of the message data may be in the same or similar color as the other displays. For example, in an embodiment, the multi-mode display **206**, the bar **212**, and the pulse display **216** may all display data or messages in orange when the multi-mode display **206** displays measured HbCO values.

FIG. **2** also illustrates the monitor **200** comprising user input keys **218**, including a HbCO button **220**, mode/enter button **222**, next button **224**, power on/off button **226**, up/down button **228**, and alarm silence button **230**. In an embodiment, activation of the HbCO button **220** toggles the measured value displayed in the multi-mode display **206**. For example, activation of the HbCO button **220** toggles the multi-mode display **206** from displaying measured values of SpO_2 to HbCO for about ten (10) seconds. Activation of the mode/enter button **222** or the next button **224** during the ten (10) second period returns the multi-mode display **206** back to SpO_2. A skilled artisan will also recognize that activation of the HbCO button **220** may advantageously toggle through a plurality of measured values, and that such values may be displayed for short segments and then return to SpO_2, may remain displayed until further activation of the button **220**, or the like.

Activation of the mode/enter button **222** cycles through various setup menus allowing a caregiver to select or activate certain entries within the menu setup system, including alarm threshold customizations, or the like. Activation of the next button **224** can move through setup options within the menu setup system and in an embodiment is not active during normal patient monitoring. For example, a caregiver may activate the mode/enter button **222** and the next button **224** to specify high and low alarm thresholds for one or more of the measured parameters, to specify device sensitivity, trend settings, display customizations, color code parameters, or the like. In an embodiment, the high alarm setting for SpO_2 can range from about two percent (2%) to about one hundred percent (100%) with a granularity of about one percent (1%). The low alarm setting for SpO_2 can range from about one percent (1%) to about one hundred percent (100%) with a granularity of about one percent (1%). Moreover, the high alarm setting for pulse rate can range from about thirty (30) BPM to about two hundred and forty (240) BPM with a granularity of about five (5) BPM. The low alarm setting for pulse rate can range from about twenty five (25) BPM to about two hundred and thirty five (235) BPM with a granularity of about five (5) BPM. Other high and low ranges for other measured parameters will be apparent to one of ordinary skill in the art from the disclosure herein.

In a further embodiment, a caregiver may activate the mode/enter button **222** and the next button **224** to specify device sensitivity, such as, for example, device averaging times, probe off detection, whether to enable fast saturation calculations, or the like. Various embodiments of fast saturation calculations are disclosed in U.S. patent application Ser. No. 10/213,270, filed Aug. 5, 2002, titled "Variable Indication Estimator" and incorporated by reference herein. Using the menus, a caregiver may also advantageously enter appropriate information governing trend collection on one or more of the measured parameters, input signals, or the like.

FIG. **2** also shows the power on/off button **226**. Activation of the power on/off button **226** activates and deactivates the monitor **200**. In an embodiment, press-and-hold activation for about two (2) seconds shuts the monitor **200** off. In an additional embodiment, activation of the on/off button **226** advantageously initiates detection of a type of attached sensor. For example, activation of the on/off button **226** may advantageously cause the monitor **200** to read information from a memory on an attached sensor and determine whether sufficient wavelengths exist on the sensor to determine one or more the physiological parameters discussed in the foregoing.

An artisan will recognize from the disclosure herein that the on/off button **226** may advantageously cause an electronic determination of whether to operate in at powers consisted with the U.S. (60 Hz) or another nationality (50 Hz). In an embodiment, such automatic determination and switching is removed from the monitor **200** in order to reduce a likelihood of problematic interfering crosstalk caused by such power switching devices.

Activation of the up/down button **228** may advantageously adjust the volume of the pulse beep tone. Additionally, activation of the up/down button **228** within the menu setup system, causes the selection of values with various menu options.

Moreover, activation of the alarm silence button **230** temporarily silences audio alarms for a predetermined period, such as, for example, about one hundred and twenty (120) seconds. A second activation of the alarm silence button **230** mutes (suspends) the alarm indefinitely, while a third activation returns the monitor **200** to standard alarm monitoring. FIG. **2** also shows the alarm silence button **230** includes an alarm silenced indicator **232**. The alarm silenced indicator **232** may advantageously flash to indicate one or more alarms are temporarily silenced, may illuminate solid to indicate the alarms have been muted, or the like. Moreover, an artisan will recognize from the disclosure herein a wide variety of alarm silencing methodologies.

The monitor **200** also includes a battery level indicator **234** indicating remaining battery life. In the illustrated embodiment, four LED's indicate the status of the battery by incrementally deactivating to indicate proportionally decreasing battery life. In an embodiment, the four LED's may also change color as the battery charge decreases, and the final LED may begin to flash to indicate that the caregiver should replace the batteries.

FIG. **2** also shows the monitor **200** including an audio transducer or speaker **236**. The speaker **236** advantageously

provides audible indications of alarm conditions, pulse tone and feedback for key-presses, or the like. Moreover, the monitor **200** includes a low signal quality indicator ("SQ" or "SIQ™") **238**. The signal IQ indicator **238** activates to inform a caregiver that a measured value of the quality of the incoming signal is below predetermined threshold values. For example, in an embodiment, the measured value for signal IQ is at least partially based on an evaluation of the plethysmograph data's correspondence to predetermined models or characteristics of physiological signals. In an embodiment, the signal IQ indicator **238** output may be associated with the displayed parameter. For example, the output may be associated with one threshold for the display of SpO_2 and another for the display of other parameter data.

The monitor **200** also comprises a perfusion quality index ("PI™") bar **240** (which quantifies the measure of perfusion of the patient) where in an embodiment a plurality of LED's activate from a bottom toward a top such that the bar "fills" to a level proportional to the measured value. In one embodiment, the PI™ bar **240** shows a static value of perfusion for a given time period, such as, for example, one or more pulses. In another embodiment, or functional setting, the PI™ bar **240** may advantageously pulse with a pulse rate, may hold the last reading and optionally fade until the next reading, may indicate historical readings through colors or fades, or the like. Additionally, the PI™ bar **240** may advantageously change colors, flash, increasingly flash, or the like to indicate worsening measured values of perfusion.

The PI™ bar **240** can be used to simply indicate inappropriate occlusion due, for example, to improper attachment of the sensor **106**. The PI™ bar **240** can also be used as a diagnostic tool during low perfusion for the accurate prediction of illness severity, especially in neonates. Moreover, the rate of change in the PI™ bar **240** can be indicative of blood loss, sleep arousal, sever hypertension, pain management, the presence or absence of drugs, or the like. According to one embodiment, the PI™ bar **240** values may comprise a measurement of the signal strength of the arterial pulse as a percentage of the total signal received. For example, in one preferred embodiment, the alternating portion of at least one intensity signal from the sensor **106** may advantageously be divided by the static portion of the signal. For example, an infrared intensity signal may advantageously be used as it is less subjective to noise.

In an embodiment, a measurement below about 1.25% may indicate medical situations in need of caregiver attention, specifically in monitored neonates. Because of the relevance of about 1.25%, the PI™ bar **240** may advantageously include level indicia **242** where the indicia **242** swap sides of the PI™ bar **240**, thus highlighting any readings below about that threshold. Moreover, behavior of the PI™ bar **240**, as discussed above, may advantageously draw attention to monitored values below such a threshold.

As discussed above, the monitor **200** may include output functionality that outputs, for example, trend perfusion data, such that a caregiver can monitor measured values of perfusion over time. Alternatively or additionally, the monitor **200** may display historical trace data on an appropriate display indicating the measured values of perfusion over time. In an embodiment, the trend data is uploaded to an external computing device through, for example, the multipurpose sensor connector **202** or other input output systems such as USB, serial or parallel ports or the like.

The monitor **200** also includes an alarm indicator **244** capable of providing visual queues of the status of one or more of the measured parameters. For example, the alarm indicator **244** may advantageously be green when all of the measured parameters are within normal conditions, may gradually fade to red, may flash, increasing flash, or the like, as one or more of the measured values approaches or passes predetermined thresholds. In an embodiment, the alarm indicator **244** activates when any parameter falls below an associated threshold, thereby advantageously informing a caregiver that perhaps a nondisplayed parameters is at an alarm condition. In another embodiment, the alarm indicator **244** may indicate the status of the parameter displayed on the multi-mode display **206**. In an embodiment, the speaker **236** may sound in conjunction with and/or in addition to the indicator **244**. Moreover, in an embodiment, an alarming parameter may automatically be displayed, may be emphasized, flashed, colored, combinations of the same or the like to draw a user's attention to the alarming parameter.

Although the foregoing invention has been described in terms of certain preferred embodiments, other embodiments will be apparent to those of ordinary skill in the art from the disclosure herein.

FIG. **3** illustrates an exemplary display of the patient monitor **200**. As shown in FIG. **3**, the display includes the multi-mode display **206**, the pulse rate display **216**, parameter indicators **208**, **210**, the HbCO bar **212** and indicator **204**, the PI™ bar **240**, and the alarm indicator **244**. In an embodiment, the multi-mode display **206** and the pulse rate display **216** each comprise a plurality of seven segment displays **302** capable of displaying alpha-numeric information. As disclosed in the foregoing, the exemplary display may advantageously include color-coded parameter displays. Moreover, the exemplary display may include color progressions, flashing, flashing progressions, audible alarms, audible progressions, or the like, indicating worsening measured values of physiological data. In addition, in an embodiment, some or all of the displays may flash at a first rate to indicate attempts to acquire data when actual measured values are unavailable. Moreover, some or all of the display may flash at a second rate to indicate low signal quality where confidence is decreasing that the measured values reflect actual physiological conditions.

FIG. **4** illustrates the display of FIG. **3** showing measured values of SpO_2, BPM, perfusion, and type of sensor, according to an exemplary embodiment of the patient monitor of FIG. **1**. As shown in FIG. **4**, the multi-mode display **206** is displaying a percentage value of SpO_2, and the pulse rate display **216** is displaying a pulse rate in beats per minute. Accordingly, the parameter indicator **210** is activated to confirm the display of measured values of SpO_2. As disclosed in the foregoing, in an embodiment, the multi-mode display **206** is red, indicating blood oxygen measurements while the pulse rate display **216** is green, indicating normal values of a patient's pulse.

FIG. **4** also shows the PI™ bar **240** almost fully activated, representing good perfusion. In addition, the HbCO indicator **204** is showing communication with a sensor producing insufficient data to determine measured values of additional parameters, such as, HbCO. In an embodiment, such sensors may comprise sensors capable of emitting light at about two (2) different wavelengths, may comprise sensors with insufficient data stored on a memory associated therewith, or the like.

FIG. **5** illustrates the display of FIG. **3** showing measured values of HbCO, perfusion, and type of sensor, according to an exemplary embodiment of the patient monitor of FIG. **1**. As shown in FIG. **5**, the multi-mode display **206** is displaying a percentage value of HbCO, and the pulse rate display **216** is displaying an appropriate message indicating the HbCO measurement, such as, for example, "CO". Also, the multi-mode display **206** has shifted the data to the left to quickly and

efficiently indicate that the displayed parameter is other than SpO_2. Accordingly, the parameter indicator **208** is also activated to confirm the display of measured values of HbCO. As disclosed in the foregoing, in an embodiment, the multi-mode display **206** and pulse rate display message **216** are orange.

FIG. **5** also shows the PI™ bar **240** almost fully activated, representing good perfusion. In addition, the activation of the HbCO indicator **204** represents communication with a sensor capable of producing sufficient data to determine measured values of HbCO. In an embodiment, such sensors may comprise sensors capable of emitting light at about eight (8) or more different wavelengths; however, such sensors may comprise about two (2) or more different wavelengths. Moreover, such sensors may have appropriate data stored on a memory associated therewith, or the like. FIG. **5** also shows the HbCO measurement being about 20% (as illustrated on the HbCO bar **212** and multi-mode display **206**) thereby indicating a potentially dangerous situation that if exacerbated, will become quite problematic. Therefore, the alarm indicator **244** is also activated, and in some embodiments, the speaker **236** as well.

FIG. **6** illustrates the display of FIG. **3** showing measured values of SpO_2, HbCO, BPM, perfusion, and type of sensor, according to an exemplary embodiment of the patient monitor of FIG. **1**. In contrast to FIG. **4**, FIG. **6** shows that the monitor **200** is communicating with a sensor capable of producing sufficient data to determine measured values of HbCO, even though the displayed values are that of SpO_2 and BPM. Thus, FIG. **6** shows the activation of the HbCO indicator **204**, and the continuous monitoring of HbCO by the HbCO bar **212**. FIG. **6** also shows a high value of HbCO, and therefore, the indication of an alarm condition by activation of the alarm indicator **244**. In an embodiment, upon determination of an alarm condition on a nondisplayed parameter, the monitor **200** may advantageously provide an alarm indication through speaker and alarm indicator activation, automatic toggle to the nondisplayed parameter on the multi-mode display **206** for a defined or undefined time, or the like.

FIG. **7** illustrates a top elevation view of an exemplary handheld noninvasive multi-parameter patient monitor **700** capable of displaying at least HbCO and HbMet, such as, for example, the patient monitor of FIG. **1**. Patient monitors exhibiting combinations of many of the features described herein are advantageously commercially available from Masimo under the brand name "Rad 57 cm." As shown in FIG. **7**, the monitor **700** comprises a monitor similar to monitor **200** disclosed with reference to FIG. **2**. Moreover, monitor **700** further includes a multi-mode display **706** capable of displaying, for example, measurements of HbMet and BPM. In an embodiment, the display **706** has insufficient space or display real estate to display the many parameters capable of being measured by the monitor **700**. Thus, the multi-mode display **706** may advantageously cycle through two or more measured parameters. In such embodiments, the monitor **700** may also advantageously include parameter indicators **708**, **710**, providing additional visual queues as to which parameter is currently displayed. In an embodiment, the display **706** may also cycle colors, flash rates, or other audio or visual queues providing readily identifiable information as to which measured parameter is displayed. For example, when the multi-mode display **706** displays measured values of BPM that are normal, the numbers may advantageously appear in green, while normal measured values of HbMet may appear in blue. Moreover, in an embodiment, the display **706** may flash at a predefined rate when searching for saturation and at another predefined rate when a signal quality is below a predetermined threshold.

FIG. **7** also illustrates the monitor **700** comprising user input keys **718**, including an HbCO/HbMet button **220**. In an embodiment, activation of the HbCO/HbMet button **720** toggles the measured value displayed in the multi-mode display **706**. For example, activation of the HbCO/HbMet button **720** toggles the multi-mode display **206** from displaying measured values of SpO_2 and BPM, to HbCO and HbMet for about ten (10) seconds. Activation of the mode/enter button **222** or the next button **224** during the ten (10) second period returns the multi-mode display **706** back to SpO_2 and BPM. A skilled artisan will also recognize that activation of the HbCO/HbMet button **720** may advantageously toggle through a plurality of measured values, and that such values may be displayed for short segments and then return to SpO_2 and BPM, may remain displayed until further activation of the button **720**, or the like.

The monitor **700** also comprises a coarser indication of HbMet through an HbMet bar **740**. In an embodiment, a plurality of LED's activate from a bottom toward a top such that the bar "fills" to a level proportional to the measured value, with increments at about 0.5%, about 1%, about 2%, about 3%, about 4%, about 5%, about 7.5%, about 10%, about 15% and greater than about 20%, although an artisan will recognize from the disclosure herein other useful delineations. Additionally, the HbMet bar **740** may advantageously change colors, flash, increasingly flash, or the like to indicate worsening measured values of perfusion.

Although disclosed with reference to the HbMet bar **740**, and artisan will recognize from the disclosure herein other coarse or even gross indications of HbMet, or any measured parameter. For example, a single LED may advantageously show green, yellow, and red, to indicate worsening coarse values of HbMet. Alternatively, a single LED may simply light to indicate an alarm or approaching alarm condition.

FIG. **8** illustrates an exemplary display of the patient monitor **700** of FIG. **7**. As shown in FIG. **8**, the display includes the multi-mode displays **206**, **706**, parameter indicators **208**, **210**, **708**, **710**, the HbCO bar **212** and indicator **204**, the HbMet bar **740**, and the alarm indicator **244**. In an embodiment, the multi-mode display **706** is similar to multi-mode display **206**, comprising a plurality of seven segment displays **302** capable of displaying alpha-numeric information, and capable of altering its display characteristics or aspects in a wide variety of configurations discussed with reference to the display **206**.

FIG. **9** illustrates the display of FIG. **8** showing measured values of SpO_2, BPM, HbCO, HbMet, and type of sensor according to an exemplary embodiment of the patient monitor of FIG. **1**. FIG. **9** also shows the HbMet bar **740** near the bottom and corresponding to about 1%, representing acceptable HbMet, while the HbCO bar **212** hovers at a dangerous near 20%. In addition, the HbCO indicator **204** is showing communication with a sensor producing sufficient data to determine measured values of additional parameters, such as, HbMet, HbCO or the like. In an embodiment, such sensors may comprise sensors capable of emitting light of more than two (2) different wavelengths, preferably more than four (4) different wavelengths, and more preferably eight (8) or more different wavelengths.

FIG. **10** illustrates the display of FIG. **8** showing measured values of HbCO, HbMet, and type of sensor according to an exemplary embodiment of the patient monitor of FIG. **1**. As shown in FIG. **10**, the multi-mode display **706** is displaying a percentage value of HbMet that is shifted using the parameter indicator **708**. The data has been advantageously shifted to the left to quickly and efficiently indicate that the displayed parameter is other than BPM. Accordingly, the parameter indicator **708** is also activated to confirm the display of mea-

sured values of HbMet. As disclosed in the foregoing, in an embodiment, the multi-mode display **706** is blue.

FIG. **10** also shows the HbMet bar **740** nearly empty, representing acceptable HbMet. In addition, the activation of the HbCO indicator **204** represents communication with a sensor capable of producing sufficient data to determine measured values of HbCO. In an embodiment, such sensors may have appropriate data stored on a memory associated therewith, or the like. FIG. **10** also shows the HbCO measurement being about 20% (as illustrated on the HbCO bar **212** and multi-mode display **206**) thereby indicating a potentially dangerous situation that if exacerbated, will become quite problematic. Therefore, the alarm indicator **244** is also activated, and in some embodiments, the speaker **236** as well.

FIG. **11**A illustrates a perspective view of an exemplary noninvasive multi-parameter patient monitor **1100**, such as, for example, the patient monitor of FIG. **1**. Moreover, FIGS. **11**B-**11**E illustrate exemplary display screens of the patient monitor of FIG. **11**A. As shown in FIGS. **11**A-**11**B, an embodiment of the monitor **1100** includes a display **1101** showing a plurality of parameter data. For example, the display may advantageously comprise a CRT or an LCD display including circuitry similar to that available on oximeters commercially available from Masimo Corporation of Irvine, Calif. sold under the name Radical™, and disclosed in the U.S. patents referenced above and incorporated above. However, an artisan will recognize from the disclosure herein many commercially available display components capable of displaying multiple parameter data along with the ability to display graphical data such as plethysmographs, trend traces, and the like.

In an embodiment, the display includes a measured value of SpO_2 **1102**, a measured value of pulse rate **1104** in BPM, a plethysmograph **1106**, a measured value of HbCO **1108**, a measured value of HbMet **1110**, a measured value of a perfusion quality **1112**, a measured value of Hbt **1114**, and a derived value of fractional saturation "$SpaO_2$" **116**. In an embodiment, $SpaO_2$ comprises HbO_2 expressed as a percentage of the four main hemoglobin species, i.e., HbO_2, Hb, HbCO, and HbMet.

In an embodiment, one or more of the foregoing parameter includes trending or prediction indicators **1118** showing the current trend or prediction for that corresponding parameter. In an embodiment, the indicators **1118** may advantageously comprise an up arrow, a down arrow, and a hyphen bar to indicate up trending/prediction, down trending/prediction, or neutral trending/prediction.

FIG. **11**C illustrates an exemplary display screen showing trend graph **1140** including trend line **1142** for HbMet. In an embodiment, the trend line **1142** may be advantageously colored for quick straightforward recognition of the trending parameter, may be associated with any one or more of the foregoing alarm attributes, may include trending lines for other parameters, or the like. The display screen also shows trending directional indicators **1142**, **1144** for many of the displayed physiological parameters. In an embodiment, the directional indicators **1142**, **1144** may advantageously comprises arrows showing the recent trend, predicted trend, user-customizable trend, combinations thereof, or the like for the associated parameters. In an embodiment, the directional indicators **1142**, **1144** comprises an up arrow indicating a rising trend/predicted trend, a middle bar indicating a somewhat stable trend/predicted trend, and a down arrow indicating a lowering trend/predicted trend. An artisan will recognize a wide variety of other directional indicators **1142**, **1144** from the disclosure herein.

FIG. **11**D shows an exemplary display screen in vertical format. Such vertical format could be user actuated or based on a gravity switch. FIGS. **11**E-**11**F illustrate additional displays of various physiological parameters similar to those discussed in the foregoing. being As shown in FIG. **11**G, the display includes a measured value of SpO_2 **1162**, a measured value of pulse rate **1164** in BPM, a plethysmograph **1166**, a HbCO bar **1168**, and a HbMet bar **1170**. In an embodiment, the HbCO bar **1168** and HbMet bar **1170** may advantageously behave the same or similarly to the HbCO bar **212** and HbMet bar **712**. Moreover, similar bars may advantageously display any of the physiological parameters discussed herein using display indicia appropriate to that parameter. For example, a SpO_2 or $SpaO_2$ bar may advantageously range from about 0% to about 100%, and more preferably range from about 50% to about 100%, while a Hbt bar may advantageously range from about 0 to about 30.

Moreover, similar to the disclosure above, the measured value of SpO_2 **1162** may advantageously toggle to measured values of HbCO, HbMet, Hbt, or the like based on, for example, actuation of user input keys, or the like.

In addition to the foregoing, the display may also include graphical data showing one or more color-coded or other identifying indicia for traces of trend data. Moreover, other graphical presentations may advantageously provide readily identifiable indications of monitored parameters or combinations of monitored parameters of the patient. For example, in an embodiment, the display includes a $SpaO_2$ graph **1172**. The $SpaO_2$ graph **1172** plots SpO_2 as a function of other blood analytes (1-$SpaO_2$), where $SpaO_2$ comprises HbO_2 expressed as a percentage of the four main hemoglobin species, i.e., HbO_2, Hb, HbCO, and HbMet. Thus, as shown in FIG. **11**C, as the slope of the displayed line or arrow increases, the caregiver can readily note that the majority of hemoglobin carriers are being used to carry oxygen, and not, for example, harmful carbon monoxide. On the other hand, as the slope decreases, the caregiver can readily and advantageously note that the number of hemoglobin species available to carry oxygen is decreasing, regardless of the current value of SpO_2. Moreover, the length of the arrow or line also provides an indication of wellness, e.g., the higher the line the more oxygen saturation, the lower the line, the more likely there may be desaturation event, or the like.

Thus, the $SpaO_2$ graph **1172** provides the caregiver with the ability to recognize that even though the measured value of SpO_2 may be within acceptable ranges, there are potentially an unacceptable number of hemoglobin carriers unavailable for carrying oxygen, and that other potential problems may exist, such as, for example, harmful carbon monoxide levels, or the like. In an embodiment, various alarm conditions may cause the graph **1172** to change color, flash, or any combination of alarm indications discussed in the foregoing. Moreover, FIG. **11** illustrates yet an additional display of the foregoing parameters.

An embodiment may also include the monitor **1000** advantageously defining regions of wellness/severity of the monitored patient. For example, because the graph **1172** comprises two dimensions, the monitor **1000** may advantageously define regions where the patient's measured physiological parameters are considered acceptable, regions where the patient is considered at risk, regions where the patient is critical, and the like. For example, one region of acceptability may include a high SpO_2 and a low 1-$SpaO_2$, another region of risk may include a high SpO_2 and a high 1-$SpaO_2$, and another critical region may include a low SpO_2 and a high 1-$SpaO_2$. Moreover, an artisan will recognize from the dis-

closure herein that different parameters may also be combined to provide readily identifiable indications of patient wellness.

In addition to or as an alternative to the two dimensional $SpaO_2$ graph **1172**, the monitor **1000** may also include a three dimensional graph, such as, for example, extending the graph **1172** along the variable of time. In this embodiment, the forgoing regions advantageously become three dimensional surfaces of wellness. Moreover, trend data may also be advantageously added to the surface to provide a history of when particular monitored parameters dipped in and out of various surfaces of wellness, risk, criticality, or the like. Such trend data could be color-coded, text identified, or the like. An artisan will also recognize that such surfaces may be dynamic. For example, measurements of HbCO> about 5 may dictate that trend data showing SpO_2< about 90% should be considered critical; however, measurements of HbCO< about 5 may dictate only SpO_2< about 85% would be critical. Again, an artisan will recognize from the disclosure herein other parameter combinations to create a wide variety of wellness/critical regions or surfaces that provide readily available visual or audio indications of patient well being, trigger specific alarms, or the like.

Moreover, the monitor **1000** may advantageously employ enlargement or reorganization of parameter data based on, for example, the severity of the measurement. For example, the monitor **1000** may display values for HbCO in a small portion of the screen or in the background, and when HbCO begins to approach abnormal levels, the small portion may advantageously grown as severity increases, even in some embodiments to dominate the display. Such visual alarming can be combined with audio alarms such as announcements, alarms, rising frequencies, or the like, and other visual alarms such as flashing, coloration, or the like to assist a caregiver in noticing the increasing severity of a monitored parameter. In an embodiment, a location of the display of an alarming value is changed to be displayed in a larger display area, such as **1102**, so as to be readily noticeable and its display values readily ascertainable.

Although the foregoing invention has been described in terms of certain preferred embodiments, other embodiments will be apparent to those of ordinary skill in the art from the disclosure herein. For example, the monitor **100** may advantageously be adapted to monitor or be included in a monitor capable of measuring physiological parameters other than those determined through absorption spectroscopy, such as, for example, blood pressure, ECG, EKG, respiratory rates, volumes, inputs for blood pressure sensors, acoustical sensors, and the like. Moreover, the monitor **100** may be adapted for wireless communication to and from the sensor **106**, and/or to and from other monitoring devices, such as, for example, multi-parameter or legacy monitoring devices.

Also, other combinations, omissions, substitutions and modifications will be apparent to the skilled artisan in view of the disclosure herein. Accordingly, the present invention is not intended to be limited by the reaction of the preferred embodiments, but is to be defined by reference to the appended claims.

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 patient monitor capable of measuring at least two physiological parameters, the patient monitor comprising a display capable of displaying a measured value of a first physiological parameter of body tissue of a monitored patient in a first display area or displaying a measured value of a second physiological parameter of the body tissue in a second display area where the first display area and the second display area comprise at least some common display area capable of displaying information, wherein the common display area changes from displaying one of the measured values of the first or second physiological parameter to displaying the other of the measured values based on an occurrence of an event, the event being the measured value of one of the first or second physiological parameters approaching one or more threshold values indicative of a worsening state of a patient.

2. The patient monitor of claim **1**, wherein the first display area and the second display area comprise the common display area.

3. The patient monitor of claim **1**, wherein activation of a user input causes the common display area to change from displaying one of the measured value of the first or second physiological parameter to displaying the other of the measured value of the first or second physiological parameter.

4. The patient monitor of claim **1**, wherein the common display area is configured to default to displaying one of the measured values of the first or second physiological parameters.

5. The patient monitor of claim **1**, wherein the measured value of the first physiological parameter comprises an invasively measured value.

6. The patient monitor of claim **1**, wherein the measured value of the first physiological parameter comprises a non-invasively measured value.

7. The patient monitor of claim **1**, wherein the measured value of the first physiological parameter comprises glucose.

8. The patient monitor of claim **1**, wherein the measured value of the first physiological parameter comprises an indication of oxygen saturation and the measured value of the second physiological parameter comprises an indication of carbon monoxide saturation.

9. The patient monitor of claim **1**, wherein the measured value of the first physiological parameter comprises an indication of oxygen saturation and the measured value of the second physiological parameter comprises an indication of methemoglobin saturation.

10. The patient monitor of claim **1**, wherein the measured value of the first physiological parameter comprises an indication of carbon monoxide saturation and the measured value of the second physiological parameter comprises an indication of methemoglobin saturation.

11. The patient monitor of claim **1**, wherein an aspect of the display changes to illustrate a change in the severity of one of the measured values of the first or second physiological parameters.

12. The patient monitor of claim **11**, wherein the aspect that changes comprises a display color.

13. The patient monitor of claim **11**, wherein the aspect that changes comprises a display size.

14. The patient monitor of claim **11**, wherein the aspect that changes comprises a display intensity.

15. A patient monitor capable of measuring at least two physiological parameters, the patient monitor comprising a display capable of displaying a measured value of a first physiological parameter of body tissue of a monitored patient in a first display area or displaying a measured value of a second physiological parameter of the body tissue in a second display area where the first display area and the second display area comprise at least some common display area capable of displaying information, wherein the common display area changes from displaying one of the measured values

of the first or second physiological parameters to displaying the other of the measured values of the first or second physiological parameters based on an occurrence of an event, the event being one of the measured values of the first or second physiological parameters alarming.

16. The patient monitor of claim **15**, wherein an aspect of an alarm changes when the common display area changes from displaying one of the measured values of the first or second physiological parameters.

17. The patient monitor of claim **16**, wherein the aspect that changes comprises a display color.

18. A patient monitor capable of measuring at least two physiological parameters, the patient monitor comprising a display capable of displaying a measured value of a first physiological parameter of body tissue of a monitored patient in a first display area or displaying a measured value of a second physiological parameter of the body tissue in a second display area where the first display area and the second display area comprise at least some common display area capable of displaying information, wherein the common display area changes from displaying one of the measured values of the first or second physiological parameters to displaying the other of the measured values of the first or second physiological parameters automatically based on which is a more critical one of the measured values of the first or second physiological parameters.

19. The patient monitor of claim **18**, wherein measured values of the first and second physiological parameters are determined using an output signal of a light sensitive detector capable of detecting light attenuated by the body tissue.

20. The patient monitor of claim **18**, wherein at least one of measured physiological parameters is determined noninvasively.

21. A method of displaying two physiological parameter measurements using a display location of a display of a patient monitoring device, the display location being generally capable of displaying a single physiological parameter measurement, the method comprising:

displaying a measured value of a first physiological parameter in a display location of an electronic display; and

replacing the display of the measured value of the first physiological parameter with a display of a measured value of a second physiological parameter in the display location when a change in the measurement of the second physiological parameter indicates a worsening state of the patient.

22. The method of claim **21**, wherein the indication of the worsening state comprises an alarm condition.

23. The method of claim **21**, wherein the measured value of the first physiological parameter comprises an invasively measured value.

24. The method of claim **21**, wherein the measured value of the first physiological parameter comprises an indication of oxygen saturation and the measured value of the second physiological parameter comprises an indication of carbon monoxide saturation.

25. The method of claim **21**, wherein the measured value of the first physiological parameter comprises an indication of oxygen saturation and the measured value of the second physiological parameter comprises an indication of methemoglobin saturation.

26. The method of claim **21**, wherein the measured value of the first physiological parameter comprises an indication of carbon monoxide saturation and the measured value of the second physiological parameter comprises an indication of methemoglobin saturation.

27. A patient monitor capable of determining a plurality of physiological parameters from an output signal of a light sensitive detector capable of detecting light attenuated by body tissue, the patient monitor comprising:

a display capable of displaying a measured value of a first blood parameter of body tissue of a monitored patient or displaying a measured value of a second blood parameter of the body tissue; and

a user input button, the activation of which causes the display to change from displaying the measured value of the first blood parameter to displaying the measured value of the second blood parameter, wherein the display also changes from displaying the measured value of the first blood parameter to displaying the measured value of the second blood parameter when the second blood parameter passes an alarm threshold,

wherein the measured values of the first and second blood parameters are determined using an output signal of a noninvasive light sensitive detector capable of detecting light attenuated by the body tissue.

28. The patient monitor of claim **27**, wherein the display shifts a positioning of the display of the second blood parameter with respect to a positioning of the display of the first blood parameter.

29. The patient monitor of claim **27**, wherein the change is for a predetermined duration and after expiration of the predetermined duration, the display changes back to displaying the measured value of the first blood parameter.

30. The patient monitor of claim **27**, wherein the display of the measured value of the first blood parameter comprises a first color under normal conditions and the display of the measured value of the second blood parameter comprises a second color under normal conditions.

31. The patient monitor of claim **27**, further comprising a sensor indicator capable of indicating whether an attached sensor can provide sufficient data to determine the measured value of the second blood parameter.

32. The patient monitor of claim **27**, wherein the attached sensor can provide data through the output signal and through a memory device.

33. The patient monitor of claim **27**, wherein the display displays the first blood parameter when the attached sensor cannot provide the sufficient data.

34. The patient monitor of claim **27**, further comprising a memory for storing trend data on one or more of the first and second blood parameters.

35. The patient monitor of claim **27**, further comprising an indicator capable of indicating the signal quality of the signals used to determine at least one of the measured values of the first and second blood parameters.

36. The patient monitor of claim **27**, further comprising an alarm corresponding to either of the measured values of the first and second blood parameters falling below predetermined associated threshold values.

37. The patient monitor of claim **36**, wherein the alarm comprises at least one of an audio or visual alarm.

38. The patient monitor of claim **27**, further comprising an additional display indicating perfusion through the body tissue.

39. The patient monitor of claim **27**, wherein the first blood parameter comprises a percent oxygen saturation and the second blood parameter comprises a percent carbon monoxide saturation.

40. The patient monitor of claim **39**, comprising an additional display capable of indicating the percent carbon monoxide saturation.

41. The patient monitor of claim 39, comprising an additional display capable of indicating the percent methemoglobin saturation.

42. The patient monitor of claim 27, wherein the display comprises a first display and the patient monitor further comprises a second display capable of displaying a pulse rate.

43. The patient monitor of claim 42, wherein the second display is capable of displaying the pulse rate when the first display displays the measured value of the first blood parameter.

44. The patient monitor of claim 42, wherein the second display is capable of displaying indicia identifying the second blood parameter when the first display displays the measured value of the second blood parameter.

45. The patient monitor of claim 27, wherein a first activation type of the user input button causes the change to be for a predetermined duration and wherein a second activation type causes the change to be for an undetermined duration.

46. The patient monitor of claim 45, wherein the first activation type comprises a first depression of the user input button and the second activation type comprises an additional depression of the user input button.

47. The patient monitor of claim 45, wherein the first activation type comprises a short duration first depression of the user input button and the second activation type comprises a long duration first depression of the user input button.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,190,223 B2
APPLICATION NO. : 11/367033
DATED : May 29, 2012
INVENTOR(S) : Ammar Al-Ali et al.

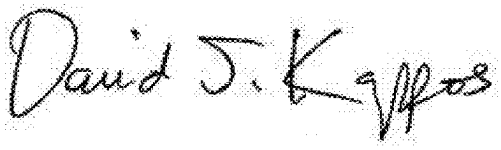
It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On Title Page 2 (Item 56), Column 1, Line 15 (Approx.), Under U.S. Patent Documents, below "Martin" insert --4,854,328 |08-1989 |Pollack--.

On Title Page 4 (Item 56), Column 1, Line 75, Under U.S. Patent Documents, change "Chin et al." to --O'Neil et al.--.

In Column 18, Line 54, change "11" to --11**H**--.

Signed and Sealed this
Thirteenth Day of November, 2012



David J. Kappos
Director of the United States Patent and Trademark Office

US008190223C1

(12) EX PARTE REEXAMINATION CERTIFICATE (9610th)

United States Patent

Al-Ali et al.

(10) Number: US 8,190,223 C1

(45) Certificate Issued: Apr. 24, 2013

(54) **NONINVASIVE MULTI-PARAMETER PATIENT MONITOR**

(75) Inventors: **Ammar Al-Ali**, Tustin, CA (US); **Joe Kiani**, Laguna Niguel, CA (US); **Mohamed Diab**, Mission Viejo, CA (US); **Greg Olsen**, Irvine, CA (US); **Roger Wu**, Irvine, CA (US); **Rick Fishel**, Orange, CA (US)

(73) Assignee: **Cercacor Laboratories, Inc.**, Irvine, CA (US)

Reexamination Request:
No. 90/012,559, Sep. 13, 2012

Reexamination Certificate for:

Patent No.:	**8,190,223**
Issued:	**May 29, 2012**
Appl. No.:	**11/367,033**
Filed:	**Mar. 1, 2006**

Certificate of Correction issued Nov. 13, 2012

Related U.S. Application Data

(60) Provisional application No. 60/657,596, filed on Mar. 1, 2005, provisional application No. 60/657,281, filed on Mar. 1, 2005, provisional application No. 60/657,268, filed on Mar. 1, 2005, provisional application No. 60/657,759, filed on Mar. 1, 2005.

(51) **Int. Cl.**
A61B 5/00 (2006.01)

(52) **U.S. Cl.**
USPC **600/300**; 600/323; 600/324

(58) **Field of Classification Search** ..... None
See application file for complete search history.

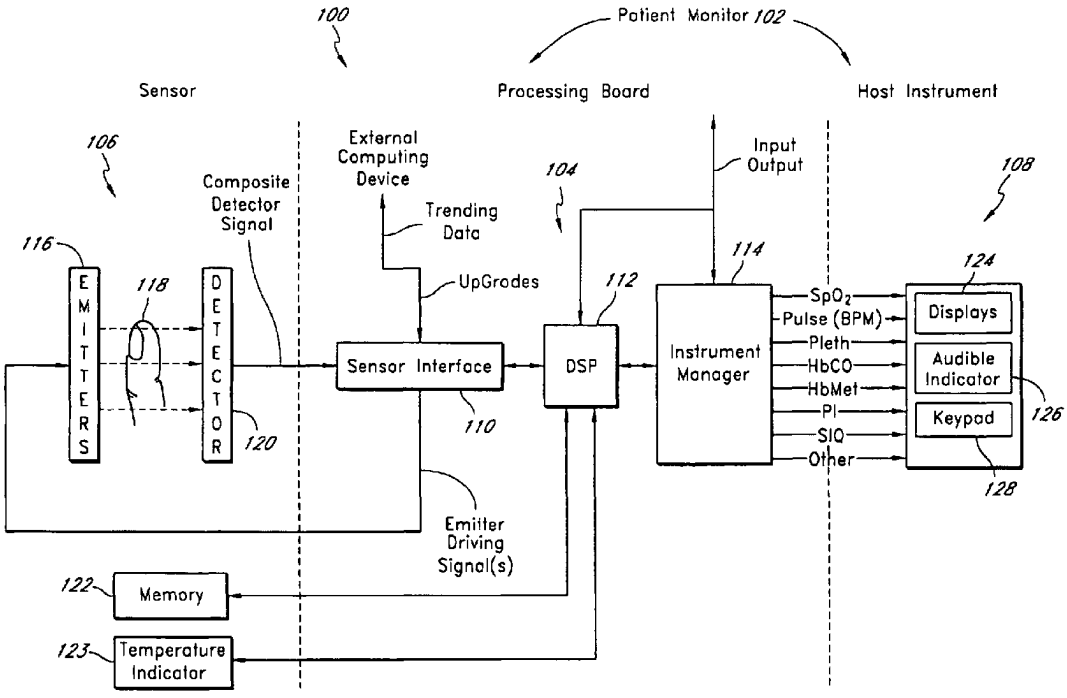
(56) **References Cited**

To view the complete listing of prior art documents cited during the proceeding for Reexamination Control Number 90/012,559, please refer to the USPTO's public Patent Application Information Retrieval (PAIR) system under the Display References tab.

Primary Examiner — Robert Nasser

(57) **ABSTRACT**

Embodiments of the present disclosure include a handheld multi-parameter patient monitor capable of determining multiple physiological parameters from the output of a light sensitive detector capable of detecting light attenuated by body tissue. For example, in an embodiment, the monitor is capable of advantageously and accurately displaying one or more of pulse rate, plethysmograph data, perfusion quality, signal confidence, and values of blood constituents in body tissue, including for example, arterial carbon monoxide saturation ("HbCO"), methemoglobin saturation ("HbMet"), total hemoglobin ("Hbt"), arterial oxygen saturation ("SpO_2"), fractional arterial oxygen saturation ("$SpaO_2$"), or the like. In an embodiment, the monitor advantageously includes a plurality of display modes enabling more parameter data to be displayed than the available physical display real estate.



EX PARTE REEXAMINATION CERTIFICATE ISSUED UNDER 35 U.S.C. 307

THE PATENT IS HEREBY AMENDED AS INDICATED BELOW.

Matter enclosed in heavy brackets [ ] appeared in the patent, but has been deleted and is no longer a part of the patent; matter printed in italics indicates additions made to the patent.

AS A RESULT OF REEXAMINATION, IT HAS BEEN DETERMINED THAT:

The patentability of claims **21-26** is confirmed.

Claims **1**, **3**, **7**, **13**, **15**, **18**, **27-28** and **45** are determined to be patentable as amended.

Claims **2**, **4-6**, **8-12**, **14**, **16-17**, **19-20**, **29-44** and **46-47**, dependent on an amended claim, are determined to be patentable.

1. A patient monitor capable of measuring at least two physiological parameters, the patient monitor comprising a display capable of displaying a measured value of a first physiological parameter of body tissue of a monitored patient in a first display area or displaying a measured value of a second physiological parameter of the body tissue in a second display area where the first display area and the second display area comprise at least some common display area capable of displaying information, wherein *in* the common display area **[**changes from displaying**]** *, the display of* one of the measured values of the first or second physiological parameter **[**to displaying**]** *is replaced with* the other of the measured values based on an occurrence of an event, the event being the measured value of one of the first or second physiological parameters approaching one or more threshold values indicative of a worsening state of a patient.

3. The patient monitor of claim **1**, wherein activation of a user input causes the common display area to **[**change from displaying**]** *replace* one of the measured value of the first or second physiological parameter **[**to displaying**]** *with* the other of the measured value of the first or second physiological parameter.

7. **[**The patient monitor of claim **1]** *A patient monitor capable of measuring at least two physiological parameters, the patient monitor comprising a display capable of displaying a measured value of a first physiological parameter of body tissue of a monitored patient in a first display area or displaying a measured value of a second physiological parameter of the body tissue in a second display area where the first display area and the second display area comprise at least some common display area capable of displaying information, wherein the common display area changes from displaying one of the measured values of the first or second physiological parameter to displaying the other of the measured values based on an occurrence of an event, the event being the measured value of one of the first or second physiological parameters approaching one or more threshold values indicative of a worsening state of a patient*, wherein the measured value of the first physiological parameter comprises glucose.

13. **[**The patient monitor of claim 11**]** *A patient monitor capable of measuring at least two physiological parameters, the patient monitor comprising a display capable of displaying a measured value of a first physiological parameter of body tissue of a monitored patient in a first display area or displaying a measured value of a second physiological parameter of the body tissue in a second display area where the first display area and the second display area comprise at least some common display area capable of displaying information, wherein the common display area changes from displaying one of the measured values of the first or second physiological parameter to displaying the other of the measured values based on an occurrence of an event, the event being the measured value of one of the first or second physiological parameters approaching one or more threshold values indicative of a worsening state of a patient, wherein an aspect of the display changes to illustrate a change in the severity of one of the measured values of the first or second physiological parameters*, wherein the aspect that changes comprises a display size.

15. A patient monitor capable of measuring at least two physiological parameters, the patient monitor comprising a display capable of displaying a measured value of a first physiological parameter of body tissue of a monitored patient in a first display area or displaying a measured value of a second physiological parameter of the body tissue in a second display area where the first display area and the second display area comprise at least some common display area capable of displaying information, wherein *in* the common display area **[**changes from displaying**]**, *the display of* one of the measured values of the first or second physiological parameters **[**to displaying**]** *is replaced with* the other of the measured values of the first or second physiological parameters based on an occurrence of an event, the event being one of the measured values of the first or second physiological parameters alarming.

18. A patient monitor capable of measuring at least two physiological parameters, the patient monitor comprising a display capable of displaying a measured value of a first physiological parameter of body tissue of a monitored patient in a first display area or displaying a measured value of a second physiological parameter of the body tissue in a second display area where the first display area and the second display area comprise at least some common display area capable of displaying information, wherein *in* the common display area **[**changes from displaying**]**, *the display of* one of the measured values of the first or second physiological parameters **[**to displaying**]** *is replaced with* the other of the measured values of the first or second physiological parameters automatically based on which is a more critical one of the measured values of the first or second physiological parameters.

27. A patient monitor capable of determining a plurality of physiological parameters from an output signal of a light sensitive detector capable of detecting light attenuated by body tissue, the patient monitor comprising:

a display capable of displaying a measured value of a first blood parameter of body tissue of a monitored patient or displaying a measured value of a second blood parameter of the body tissue; and

a user input button, the activation of which **[**causes**]** *replaces* the display **[**to change from displaying**]** *of* the measured value of the first blood parameter **[**to displaying**]** *with* the measured value of the second blood parameter, wherein the display **[**also changes from displaying**]** *of* the measured value of the first blood parameter **[**to displaying**]** *is replaced by* the measured value of the second blood parameter when the second blood parameter passes an alarm threshold,

wherein the measured values of the first and second blood parameters are determined using an output signal of a

noninvasive light sensitive detector capable of detecting light attenuated by the body tissue.

28. [The patient monitor of claim **27**] *A patient monitor capable of determining a plurality of physiological parameters from an output signal of a light sensitive detector capable of detecting light attenuated by body tissue, the patient monitor comprising:*

a display capable of displaying a measured value of a first blood parameter of body tissue of a monitored patient or displaying a measured value of a second blood parameter of the body tissue; and

a user input button, the activation of which causes the display to change from displaying the measured value of the first blood parameter to displaying the measured value of the second blood parameter, wherein the display also changes from displaying the measured value of the first blood parameter to displaying the measured value of the second blood parameter when the second blood parameter passes an alarm threshold,

wherein the measured values of the first and second blood parameters are determined using an output signal of a noninvasive light sensitive detector capable of detecting light attenuated by the body tissue,

wherein the display shifts a positioning of the display of the second blood parameter with respect to a positioning of the display of the first blood parameter.

45. [The patient monitor of claim **27**] *A patient monitor capable of determining a plurality of physiological parameters from an output signal of a light sensitive detector capable of detecting light attenuated by body tissue, the patient monitor comprising:*

a display capable of displaying a measured value of a first blood parameter of body tissue of a monitored patient or displaying a measured value of a second blood parameter of the body tissue; and

a user input button, the activation of which causes the display to change from displaying the measured value of the first blood parameter to displaying the measured value of the second blood parameter, wherein the display also changes from displaying the measured value of the first blood parameter to displaying the measured value of the second blood parameter when the second blood parameter passes an alarm threshold,

wherein the measured values of the first and second blood parameters are determined using an output signal of a noninvasive light sensitive detector capable of detecting light attenuated by the body tissue,

wherein a first activation type of the user input button causes the change to be for a predetermined duration and wherein a second activation type causes the change to be for an undetermined duration.

* * * * *