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Isaacson

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(54) **OPTICAL SENSOR PATH SELECTION**
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3,704,706 A	12/1972	Herczfeld et al.
3,709,612 A	1/1973	Clemens
3,866,599 A	2/1975	Johnson
3,998,550 A	12/1976	Konishi et al.
4,014,321 A	3/1977	March
4,029,085 A	6/1977	DeWitt et al.
4,086,915 A	5/1978	Kofsky et al.
4,119,406 A	10/1978	Ciemens
4,129,125 A	12/1978	Lester et al.
4,167,331 A	9/1979	Nielsen
4,222,389 A	9/1980	Rubens
4,223,680 A	9/1980	Jobsis
4,224,948 A	9/1980	Cramer et al.
4,259,963 A	4/1981	Huch

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(Continued)

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FOREIGN PATENT DOCUMENTS

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JP	05212016 A	8/1993
JP	08271600	10/1996

(Continued)

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OTHER PUBLICATIONS

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USPC **600/323; 600/357**

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(58) **Field of Classification Search**
USPC 600/323, 326, 357
See application file for complete search history.

(57) **ABSTRACT**

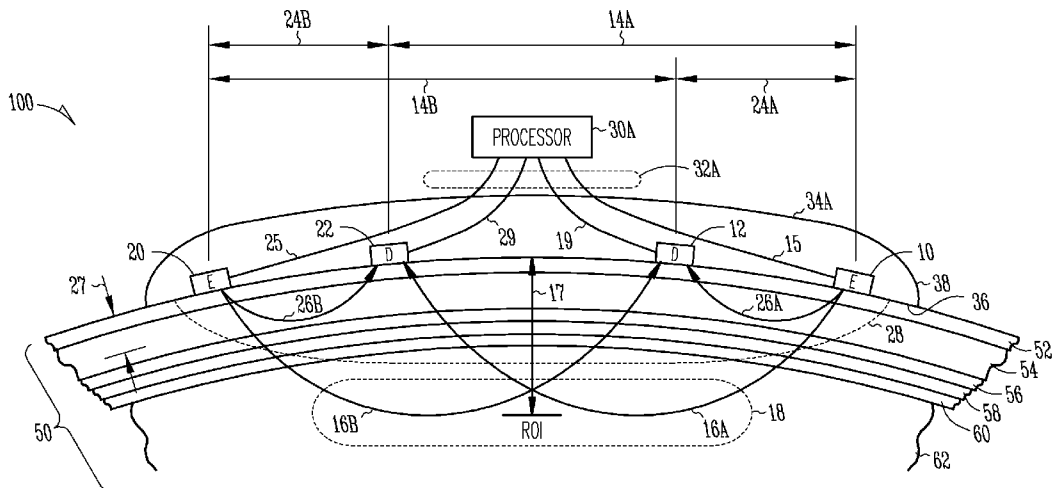
(56) **References Cited**

A device includes a sensor for measuring a parameter for tissue. The sensor includes a plurality of optical elements including a plurality of detectors and at least one emitter. Separation distances between the various optical elements are selected based on a depth corresponding to a region of interest in the tissue and based on a depth corresponding to an exclusion region in the tissue.

U.S. PATENT DOCUMENTS

2,706,927 A	4/1955	Wood
2,790,438 A	4/1957	Taplin et al.
3,412,729 A	11/1968	Smith, Jr.
3,068,742 A	8/1969	Hicks, Jr. et al.
3,461,856 A	8/1969	Polyani
3,638,640 A	2/1972	Shaw

10 Claims, 4 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

4,266,554 A 5/1981 Hamaguri
 4,281,645 A 8/1981 Jobsis
 4,321,930 A 3/1982 Jobsis et al.
 4,380,240 A 4/1983 Jobsis et al.
 4,416,285 A 11/1983 Shaw et al.
 4,447,884 A 5/1984 Wade
 4,452,250 A 6/1984 Chance et al.
 4,469,107 A 9/1984 Asmar et al.
 4,510,938 A 4/1985 Jobsis et al.
 4,576,173 A 3/1986 Parker et al.
 4,648,892 A 3/1987 Kittrell et al.
 4,655,225 A 4/1987 Dahne et al.
 4,700,708 A 10/1987 New, Jr. et al.
 4,714,341 A 12/1987 Hamaguri et al.
 4,738,267 A 4/1988 Lazorthes et al.
 4,773,422 A 9/1988 Isaacson et al.
 4,774,679 A 9/1988 Carlin
 4,800,495 A 1/1989 Smith
 4,800,885 A 1/1989 Johnson
 4,805,623 A 2/1989 Jobsis
 4,824,242 A 4/1989 Frick et al.
 4,836,207 A 6/1989 Bursell et al.
 4,840,485 A 6/1989 Gratton
 4,846,183 A 7/1989 Martin
 4,869,254 A 9/1989 Stone et al.
 4,880,304 A * 11/1989 Jaeb et al. 356/41
 4,908,762 A 3/1990 Suzuki et al.
 4,926,867 A 5/1990 Kanda et al.
 4,942,877 A * 7/1990 Sakai et al. 600/323
 4,972,331 A 11/1990 Chance
 5,032,024 A 7/1991 Cope
 5,035,243 A 7/1991 Muz
 5,057,695 A 10/1991 Hirao et al.
 5,062,431 A 11/1991 Potter
 5,074,306 A 12/1991 Green et al.
 5,088,493 A 2/1992 Giannini et al.
 5,090,415 A 2/1992 Yamashita et al.
 5,119,815 A 6/1992 Chance
 5,137,355 A 8/1992 Barbour et al.
 5,139,025 A 8/1992 Lewis et al.
 5,140,989 A 8/1992 Lewis et al.
 5,198,977 A 3/1993 Salb
 5,213,105 A 5/1993 Gratton et al.
 5,217,013 A 6/1993 Lewis et al.
 5,218,962 A 6/1993 Mannheimer et al.
 5,222,495 A 6/1993 Clarke et al.
 5,253,646 A 10/1993 Delpy et al.
 5,261,410 A 11/1993 Alfano et al.
 5,266,554 A 11/1993 Suchy et al.
 5,277,181 A 1/1994 Mendelson et al.
 5,285,783 A 2/1994 Secker
 5,318,023 A 6/1994 Vari et al.
 5,349,961 A 9/1994 Stoddart et al.
 5,385,143 A 1/1995 Aoyagi
 5,431,170 A 7/1995 Mathews
 5,465,714 A 11/1995 Scheuing
 5,477,853 A 12/1995 Farkas et al.
 5,482,031 A 1/1996 Lambert
 5,482,034 A 1/1996 Lewis
 5,490,523 A * 2/1996 Isaacson et al. 600/323
 5,497,769 A 3/1996 Gratton et al.
 5,524,617 A * 6/1996 Mannheimer 600/323
 5,529,064 A 6/1996 Rall
 5,551,422 A * 9/1996 Simonsen et al. 600/322
 5,551,423 A 9/1996 Sugiura
 5,584,269 A 12/1996 MacKenzie
 5,697,367 A 12/1997 Lewis et al.
 5,720,284 A 2/1998 Aoyagi et al.
 5,772,589 A 6/1998 Bernreuter
 5,779,631 A 7/1998 Chance
 5,792,052 A * 8/1998 Isaacson et al. 600/323
 5,795,292 A 8/1998 Lewis et al.
 5,800,349 A * 9/1998 Isaacson et al. 600/323

5,902,235 A 5/1999 Lewis et al.
 5,922,607 A 7/1999 Bernreuter
 6,226,540 B1 5/2001 Bernreuter
 6,285,895 B1 9/2001 Ristolainen et al.
 6,549,795 B1 4/2003 Chance
 6,597,931 B1 7/2003 Cheng et al.
 6,615,065 B1 9/2003 Barrett et al.
 6,985,763 B2 1/2006 Boas et al.
 7,047,054 B2 5/2006 Benni
 7,072,701 B2 * 7/2006 Chen et al. 600/331
 7,865,223 B1 1/2011 Bernreuter
 8,055,321 B2 11/2011 Bernreuter
 2002/0058865 A1 * 5/2002 Cheng et al. 600/323
 2002/0082488 A1 6/2002 Al-Ali et al.
 2002/0161290 A1 10/2002 Chance
 2002/0198443 A1 12/2002 Ting
 2003/0181798 A1 9/2003 Al-Ali
 2004/0024297 A1 2/2004 Chen et al.
 2005/0075549 A1 * 4/2005 Kondoh et al. 600/323
 2005/0228291 A1 10/2005 Chance
 2006/0189862 A1 * 8/2006 Casciani et al. 600/338
 2007/0055119 A1 3/2007 Lash et al.
 2008/0015424 A1 1/2008 Bernreuter
 2008/0058638 A1 * 3/2008 Zhu et al. 600/425
 2008/0208011 A1 * 8/2008 Shuler 600/301
 2009/0247853 A1 * 10/2009 Debreczeny 600/328
 2009/0281403 A1 11/2009 Benni
 2010/0094134 A1 * 4/2010 Zhu et al. 600/473
 2011/0060200 A1 3/2011 Bernreuter
 2012/0184830 A1 * 7/2012 Balberg et al. 600/323

FOREIGN PATENT DOCUMENTS

JP 11244268 A 9/1999
 JP 2008532680 A 8/2008
 JP 2010534083 A 11/2010
 WO WO-0181798 A1 11/2001
 WO WO-2004010844 A2 2/2004
 WO WO-2006094279 A1 9/2006
 WO WO-2006124696 A1 11/2006
 WO WO-2007012931 A2 2/2007
 WO WO-2009013608 A2 1/2009
 WO WO-2009013608 A3 1/2009

OTHER PUBLICATIONS

“U.S. Appl. No. 11/078,399, Preliminary Amendment filed Mar. 14, 2006”, 1 pg.
 “U.S. Appl. No. 11/078,399, Response filed Jul. 16, 2009 to Restriction Requirement mailed Jun. 16, 2009”, 12 pgs.
 “U.S. Appl. No. 11/078,399, Restriction Requirement mailed Jun. 16, 2009”, 7 pgs.
 “U.S. Appl. No. 11/780,997, Non-Final Office Action mailed Jun. 5, 2009”, 19 pgs.
 “U.S. Appl. No. 11/780,997, Response filed Oct. 5, 2009 to Non Final Office Action mailed Jun. 5, 2009”, 25 pgs.
 “European Application No. 06795079.0, Office Action Mailed Sep. 25, 2009”, 5 pgs.
 “International Application Serial No. PCT/IB2006/001863, International Search Report and Written Opinion mailed Sep. 18, 2007”, 13 pgs.
 “International Application Serial No. PCT/IB2006/001863, International Search Report mailed May 23, 2007”, 5 pgs.
 “International Application Serial No. PCT/IB2006/001863, Written Opinion mailed Sep. 14, 2007”, 12 pgs.
 “International Application Serial No. PCT/IB2008/001932, International Search Report and Written Opinion dated Mar. 3, 2009”, 13 pgs.
 Graaff, R., “Reduced Light-Scattering Properties for Mixtures of Spherical Particles: A Simple Approximation Derived from Mie Calculations”, *Applied Optics* 31, (1992), 1370-1376.
 Keogh, Brian F., “When Pulse Oximetry Monitoring of the Critically Ill is Not Enough”, *Anesth Analg* 94, (2002), S96-S99.

(56)

References Cited

OTHER PUBLICATIONS

Rais-Bahrami, K, et al., "Validation of a noninvasive neonatal optical cerebral oximeter in veno-venous ECMO patients with a cephalad catheter", *Journal of Perinatology*, (2006), pp. 628-635.

Schmitt, Joseph M., "Simple Photon Diffusion Analysis of the Effects of Multiple Scattering on Pulse Oximetry", *IEEE*, vol. 38, No. 12, (Dec. 1991), 1194-1203.

"U.S. Appl. No. 11/780,997, Examiner Interview Summary mailed May 26, 2011", 4 pgs.

"U.S. Appl. No. 11/780,997, Notice of Allowance mailed Jul. 12, 2011", 7 pgs.

"European Application Serial No. 06795079.0, Office Action mailed Aug. 1, 2011", 6 pgs.

"Japanese Application Serial No. 2008-501451, Notice of Reason for Rejection mailed Oct. 21, 2011", 8 pgs.

"U.S. Appl. No. 11/078,399, Non-Final Office Action mailed Dec. 3, 2009", 23 pgs.

"U.S. Appl. No. 11/078,399, Response filed Mar. 2, 2010 to Non Final Office Action mailed Dec. 3, 2009", 17 pgs.

"U.S. Appl. No. 11/780,997, Final Office Action mailed Mar. 2, 2010", 10 pgs.

"U.S. Appl. No. 11/780,997, Response filed Apr. 29, 2010 to Final Office Action mailed Mar. 2, 2010", 12 pgs.

"International Application Serial No. PCT/US2009/064360, Search Report mailed Mar. 9, 2010", 7 pgs.

"International Application Serial No. PCT/US2009/064360, Written Opinion mailed Mar. 9, 2010", 6 pgs.

"U.S. Appl. No. 11/780,997, Final Office Action mailed Apr. 8, 2011", 15 pgs.

"U.S. Appl. No. 11/780,997, Response filed Oct. 12, 2010 to Non-Final Office Action mailed Jun. 11, 2010", 15 pgs.

"U.S. Appl. No. 11/780,997, Response filed Jun. 8, 2011 to Final Office Action mailed Apr. 8, 2011", 15 pgs.

"U.S. Appl. No. 12/946,506, Preliminary Amendment mailed Jun. 23, 2011", 8 pgs.

"European Application Serial No. 06795079.0, Response filed May 25, 2010", 12 pgs.

"International Application Serial No. PCT/IB2006/001863, International Preliminary Report on Patentability mailed Sep. 18, 2007", 13 pgs.

"U.S. Appl. No. 13/283,044, Preliminary Amendment filed Apr. 10, 2012", 6 pgs.

"European Application Serial No. 06795079.0, Response filed May 16, 2012 to Office Action mailed Mar. 20, 2012", 12 pgs.

"Japanese Application Serial No. 2008-501451, Response filed Apr. 20, 2012 to Office Action mailed Oct. 21, 2011", 22 pgs.

"U.S. Appl. No. 11/078,399, Examiner Interview Summary mailed Jun. 10, 2010", 3 pgs.

"U.S. Appl. No. 11/078,399, Final Office Action mailed Jun. 10, 2010", 12 pgs.

"U.S. Appl. No. 11/078,399, Notice of Allowance mailed Sep. 1, 2010", 7 pgs.

"U.S. Appl. No. 11/078,399, Response filed Aug. 10, 2010 to Final Office Action mailed Jun. 10, 2010", 14 pgs.

"U.S. Appl. No. 11/780,997, Non-Final Office Action mailed Jun. 11, 2010", 12 pgs.

"U.S. Appl. No. 12/946,506, Non Final Office Action mailed Jan. 7, 2013", 6 pgs.

"U.S. Appl. No. 12/946,506, Notice of Allowance mailed Aug. 20, 2013", 13 pgs.

"U.S. Appl. No. 12/946,506, Response filed Jun. 7, 2013 to Non Final Office Action mailed Jan. 7, 2013", 19 pgs.

"European Application Serial No. 06795079.0, Office Action mailed Apr. 11, 2013", 5 pgs.

"International Application Serial No. PCT/IB2008/001932, International Preliminary Report on Patentability mailed Feb. 4, 2010", 8 pgs.

"International Application Serial No. PCT/US2009/064360, Preliminary Report on Patentability mailed May 17, 2011", 7 pgs.

"Japanese Application Serial No. 2008-501451, Office Action mailed Feb. 8, 2013", with English translation of claims, 7 pgs.

"Japanese Application Serial No. 2008-501451, Response filed Jul. 8, 2013 to Office Action mailed Feb. 8, 2013", w/English translation, 14 pgs.

* cited by examiner

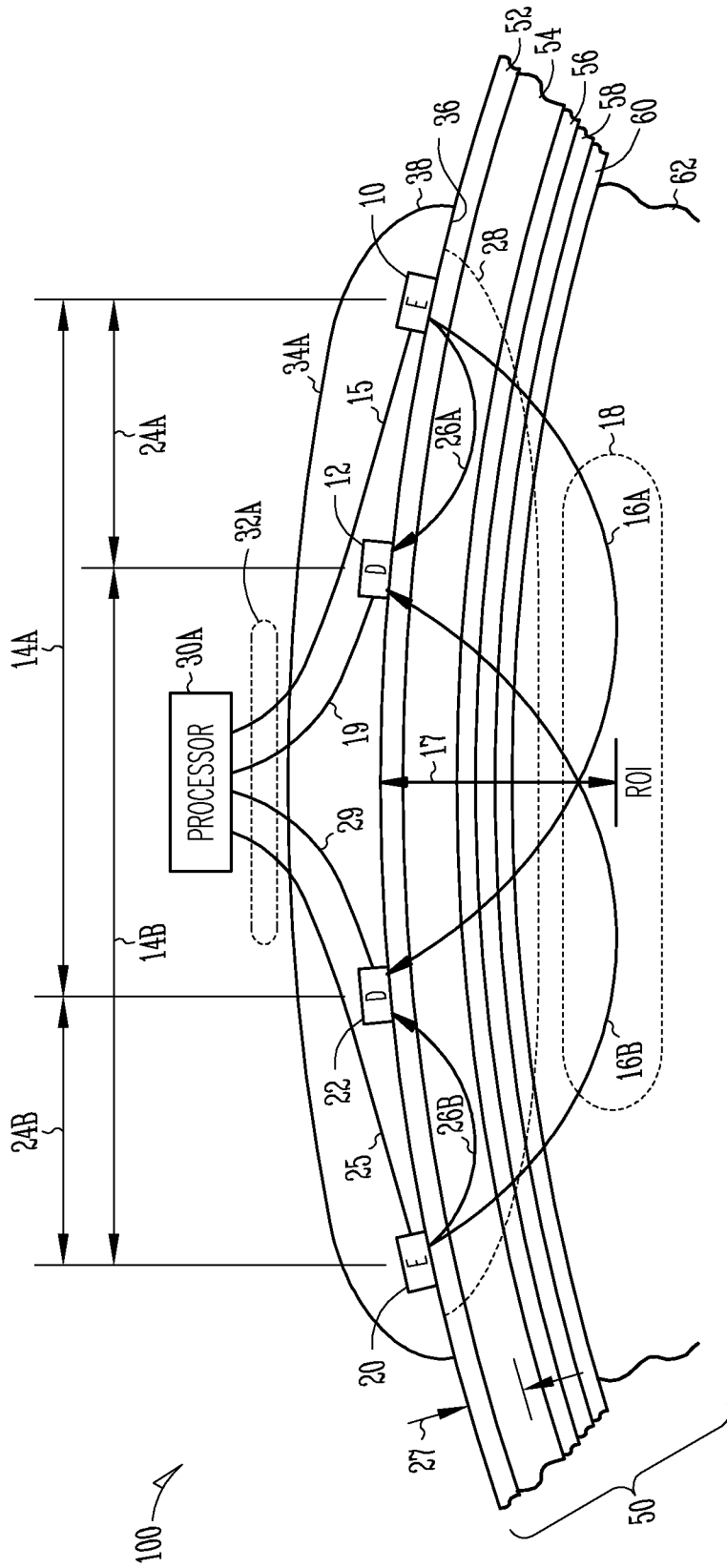


Fig. 1

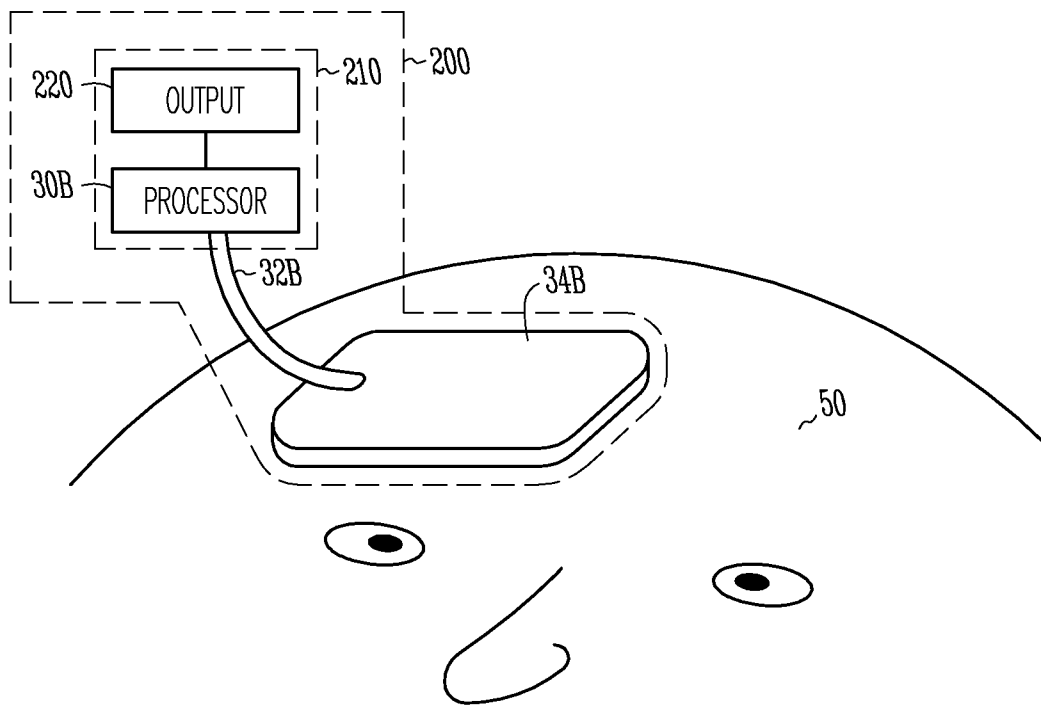


Fig. 2

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