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[54] **APPARATUS AND METHOD FOR SIMULATING LUNG SOUNDS IN A PATIENT SIMULATOR**

[75] Inventors: **Samsun Lampotang; Willem L. van Meurs; Michael L. Good; Joachim S. Gravenstein; Ronald G. Carovano**, all of Gainesville, Fla.

[73] Assignee: **University of Florida Research Foundation, Inc.**, Gainsville, Fla.

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[51] **Int. Cl.**^{6} **G09B 23/32**

[52] **U.S. Cl.** **434/266**; 434/272

[58] **Field of Search** 434/262, 265, 434/266, 267, 268, 272, 275; 128/774

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,520,071	7/1970	Abrahamson et al. .
3,564,729	2/1971	Ackerman 434/266
3,661,052	5/1972	Lucien et al. .
3,665,087	5/1972	Poylo 434/266
3,808,706	5/1974	Mosley et al. .
3,849,909	11/1974	Ravin 434/266
4,167,070	9/1979	Orden .
4,561,851	12/1985	Ferreira et al. .
4,570,640	2/1986	Barsa .
4,878,388	11/1989	Loughlin et al. .
4,907,973	3/1990	Hon .
5,314,339	5/1994	Aponte 434/262
5,397,237	3/1995	Dhont et al. 434/262
5,403,192	4/1995	Kleinwaks et al. .

OTHER PUBLICATIONS

M.L. Good, M.D., and J.S. Gravenstein, M.D., *Anesthesia Simulators and Training Device*, International Anesthesiology Clinics 27:161–164 (1989).

Good, et al., *Hybrid Lung Model for Use in Anesthesia Research and EducationAnesthesiology*, Hybrid Lung Model for Use in Anesthesia Research and Education, 71:982–984 (1989).

D.M. Gaba, M.D. and A. DeAnda, *A Comprehensive Anethesia Stimulation Environment: Re–creating the Operating Room for Research and Training*, Anesthesiology, 69:387–389 (1988).

M.L. Good, et al., *Critical Events Simulation for Training in Anesthesiology*, Journal of Clinical Monitoring, 4:140(1988).

S. Lampotang, et al., *A lung model of carbon dioxide concentrations with mechanical or spontaneous ventilation*, Critical Care Medicine, 14:1055–1057, (1986).

S. Abrahamson, *Chapter 31: Human Simulation for Training in Anesthesiology*, Medical Engineering, pp. 370–374.

J.S. Densen, M.D. and S. Abrahamson, Ph.D., *A Computer–Controlled Pateint Simulator*, JAMA, 208:504–508, (1969).

Ross, et al., *Servocontrolled Closed Circuit Anaesthesia: A method for automatic controlof anaethesia produced by a volatile agent in oxygen*, British Journal of Anesthesia, 44:1053–1060 (1983).

Primary Examiner—John P. Leubecker
Attorney, Agent, or Firm—Needle & Rosenberg, P.C.

[57] **ABSTRACT**

A method and apparatus for simulating lung sounds in real time in an integrated patient simulator uses a manikin having an associated simulated lung comprising at least one bellows and at least one sensor for sensing the position of the bellows. Based on a physiological state of the patient simulator, an audible lung sound is directed through a plurality of sound output devices located at different locations on the manikin. The lung sound corresponds to an appropriate physiological sound at that particular location on the manikin and is synchronized with the position of the bellows. Synchronization occurs by continuously determining a volume of the bellows to determine a respiratory phase and a transition in the respiratory phase. The respiratory phase is determined by calculating a first derivative of the bellows volume over time and the transition in the respiratory phase is determined by calculating a second derivative of the bellows volume over time.

4 Claims, 7 Drawing Sheets