



# United States Patent [19]

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## [54] SELF REGULATING LUNG FOR SIMULATED MEDICAL PROCEDURES

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### Related U.S. Application Data

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[51] Int. Cl.<sup>6</sup> ..... **G09B 23/28**

[52] U.S. Cl. .... **434/272; 434/262**

[58] Field of Search ..... 434/262, 265, 434/266-268, 272, 275, 366; 128/772; 364/413.02, 413.03, 413.04, 413.27; 395/924

### [56] References Cited

#### U.S. PATENT DOCUMENTS

3,520,071	7/1970	Abrahamson et al. .	
3,661,052	5/1972	Lucien et al. ....	91/173
3,808,706	5/1974	Mosley et al. ....	434/272 X
4,167,070	9/1979	Orden ..... ..	434/272
4,561,851	12/1985	Ferreira et al. .	
4,570,640	2/1986	Barsa .	
4,878,388	11/1989	Loughlin et al. ....	434/265 X
4,907,973	3/1990	Hon .	
5,403,192	4/1995	Kleinwaks et al. ....	434/272

#### OTHER PUBLICATIONS

Michael L. Good, M.D., and J. S. Gravenstein, M.D., *International Anesthesiology Clinics*, "Anesthesia Simulators and Training Devices", Vo. 27, No. 3, Fall 1989, pp. 161-164.

M. L. Good, M.D., S. Lampotang, M.E., G. Ritchie, Ph.D., J. Heffels, B. Miller, J. E. W. Beneken, Ph.D. & R. Tham, Ph.D., *Anesthesiology*, "Hybrid Lung Model for Use in Anesthesia Research and Education", vol. 71, No. 3A, Sep. 1989, pp. 982-984.

David M. Gaba, M.D. and Abe DeAnda, B.S., *Anesthesiology*, "A Comprehensive Anesthesia Simulation Environment: Re-creating the Operating Room for Research and Training", V. 69, pp. 387-394 (1988).

M. L. Good, S. Lampotang, G. L. Gibby & J. S. Gravenstein, *Journal of Clinical Monitoring*, "Critical Events Simulation for Training in Anesthesiology", Vo. 4, No. 2, Apr. 1988, p. 140.

S. Lampotang, M.E., N. Gravenstein, M.D., M. J. Banner, RRT, MEd, M. J. Jaeger, M.D., R. R. Schultetus, M.D., Ph.D., *Critical Care Medicine*, "A lung model of carbon dioxide concentrations with mechanical or spontaneous ventilation", vol. 14, No. 12, Dec. 1986, pp. 1055-1057.

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

J. S. Denson, M.D. and S. Abrahamson, Ph.D., *JAMA*, "A Computer-Controlled Patient Simulator", vol. 208, No. 3, Apr. 21, 1969, pp. 504-508.

Ross et al., *British Journal of Anesthesia*, "Servocontrolled Closed Circuit Anaesthesia: A method for the automatic control of anaesthesia produced by a volatile agent in oxygen", vol. 55, (1983) pp. 1053-1060.

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### [57] ABSTRACT

A self-regulating, simulated lung for use in real time in simulated medical procedures comprises at least one bellows capable of receiving and expelling gas, a means for actuating the bellows depending upon a time- and event-based script, a computer model or a combination thereof, at least one mass flow controller capable of directing the gas into the bellows, and a volumetric pump for continuously expelling a constant flow rate of gas from the bellows. The means for actuating the bellows comprises a double acting piston connected to the bellows and having a first constant pressure and a second variable pressure acting on respective sides of the piston, whereby non-linear compliances may be simulated.

21 Claims, 7 Drawing Sheets

