METABOLIC CALORIMETER EMPLOYING RESPIRATORY GAS ANALYSIS

REFERENCE TO RELATED APPLICATIONS

This application claims priority from U.S. provisional patent application Serial Nos. 60/146,898, filed Aug. 2, 1999; 60/155,035, filed Sep. 20, 1999; 60/219,241, filed Jul. 18, 2000; and 60/218,863, filed Jul. 18, 2000, the entire contents of all are incorporated herein by reference.

FIELD OF THE INVENTION

This invention relates to a respiratory instrument for measuring metabolism and related respiratory parameters by indirect calorimetry.

BACKGROUND OF THE INVENTION

U.S. Pat. Nos. 4,917,108; 5,038,792; 5,178,155; 5,179,958; and 5,836,300, all to Mault, a coinventor of the present application, are incorporated herein by reference. These patents disclose systems for measuring metabolism and related respiratory parameters through indirect calorimetry. These instruments generally employ flow meters which pass both the inhalations and the exhalations of a user breathing through the instrument and integrate the resulting instantaneous flow signals to determine total full flow volumes. In one embodiment, the exhaled gases generated by the user are passed through a carbon dioxide scrubber before passing through the flow meter so that the differences between the inhaled and exhaled volumes is essentially a measurement of the oxygen consumed by the lungs. In an alternative embodiment, the concentration of carbon dioxide exhaled by the user is determined by passing the exhaled volume through a capnometer and integrating that signal with the exhaled flow volume. The oxygen consumption can then be calculated as the difference between the inhaled and exhaled volumes minus the exhaled carbon dioxide volume.

The scrubber used with certain of these systems was relatively bulky and required replenishment after extended usage. The capnometers used with the instruments to measure carbon dioxide concentration had to be highly precise and accordingly expensive because any error in measurement of the carbon dioxide content of the exhalation produces a substantially higher error in the resulting determination of the oxygen content of the exhalation.

Additional approaches to indirect calorimetry and cardiac output monitoring are disclosed in Mault's co-pending applications serial numbers 09/008,435; 09/191,782; PCT/US99/02448; PCT/US99/17553; PCT/US99/27297; PCT/US00/12745, each of which are incorporated herein by reference.

SUMMARY OF THE INVENTION

The present invention provides an indirect calorimeter for measuring the metabolic rate of a subject. The calorimeter includes a respiratory connector configured to be supported in contact with the subject so as to pass inhaled and exhaled gases as the subject breathes. A flow pathway is operable to receive and pass inhaled and exhaled gases. A first end of the flow pathway is in fluid communication with the respiratory connector and a second end is in fluid communication with a source and sink for respiratory gases which may be either the ambient atmosphere, a mechanical ventilator, or other gas mixture source. A flow meter generates electrical signals as a function of the instantaneous flow volume of inhaled and exhaled gases passing through the flow pathway. A component gas concentration sensor generates electrical signals as a function of the instantaneous fraction of a predetermined component gas in the inhaled and/or exhaled gases as the gases pass through the flow pathway. A computation unit receives the electrical signals from the flow meter and the component gas concentration sensor and calculates at least one respiratory parameter for the subject as the subject breathes through the calorimeter.

In some embodiments, the flow pathway includes a flow tube through which the inhaled and exhaled gases pass and a chamber disposed between the first end of the pathway and the flow tube. The chamber surrounds one end of the flow tube and forms a concentric chamber.

In other embodiments, a flow tube forms part of the flow pathway and is disposed between the two ends of the pathway. The first end of the pathway takes the form of an inlet conduit that extends perpendicularly to the flow tube.

In some embodiments, the flow pathway includes an elongated flow tube through which inhalation and exhalation gases pass. The flow meter is an ultrasonic flow meter and includes two spaced apart ultrasonic transducers. The transducers are each aligned with the elongated flow tube such that ultrasonic pulses transmitted between the transducers travel in a path that is generally parallel to the flow of fluid in the flow tube.

Yet other embodiments of the present invention are also disclosed in the following description and the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Other advantages and applications of the present invention will be made apparent by the following detailed description of preferred embodiments of the invention. The description makes reference to the accompany drawings in which:

FIG. **1** is a perspective view of a respiratory calorimeter according to a first embodiment of the present invention with the calorimeter shown being used by a user;

FIG. **2** is a perspective view of the first embodiment of the invention;

FIG. **3** is a perspective view in exploded form of the first embodiment of the invention;

FIG. **4** is a cross sectional view of the first embodiment of the invention, taken along lines **4**—**4** in FIG. **2**;

FIG. **5** is a cross sectional view of the first embodiment of the invention, taken along lines **5**—**5** in FIG. **4**;

FIG. **6** is a perspective view in exploded form of one embodiment of an oxygen sensor for use with the present invention;

FIG. **7** is a cross sectional view of an assembled oxygen sensor for use with the present invention;

FIG. **8** is a perspective view of the present invention with an alternative mouthpiece, shown with the disposable portion removed from the reusable portion;

FIG. **9** is a cross sectional view of an alternative approach to constructing an oxygen sensor for use with the present invention;

FIG. **10** is a diagram showing the general configuration of a flow tube and ultrasonic sensors according to the present invention;

FIG. **11** is a schematic showing the electronic circuitry for use with an embodiment of an ultrasonic flow sensing system that may be used with the present invention;

FIG. **12** is a schematic showing an drive signal and fluorescence response signal for a fluorescence based oxygen sensor for use with the present invention;