US 20080251070A1

(19) United States
(12) Patent Application Publication
Pinskiy et al.
(10) Pub. No.: US 2008/0251070 A1
(43) Pub. Date: Oct. 16, 2008

(54) METHOD AND APPARATUS FOR CAPNOGRAPHY-GUIDED INTUBATION

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(21) Appl. No.: **11/982,711**

(22) Filed: **Nov. 2, 2007**

Related U.S. Application Data

(60) Provisional application No. 60/856,109, filed on Nov. 2, 2006.

Publication Classification

(51) **Int. Cl.**
A61M 16/00 (2006.01)

(52) **U.S. Cl.** **128/202.22**

(57) ABSTRACT

A method and apparatus for qualitative sensory signal, capnography-guided intubation is provided. A qualitative sensory signal, such as an audible signal, is generated during intubation of a patient to provide an audible indication of carbon dioxide levels, so as to facilitate proper placement of an intubation tube. The frequency of the audible signal corresponds to measured carbon dioxide levels, thereby providing a simple, easy-to-interpret, audible indication of the current position of an endotracheal tube during intubation, as well as confirmation of proper placement of the tube. Alternatively, the qualitative sensor signal may be an omni-directional visual signal or a palpable vibratory signal.

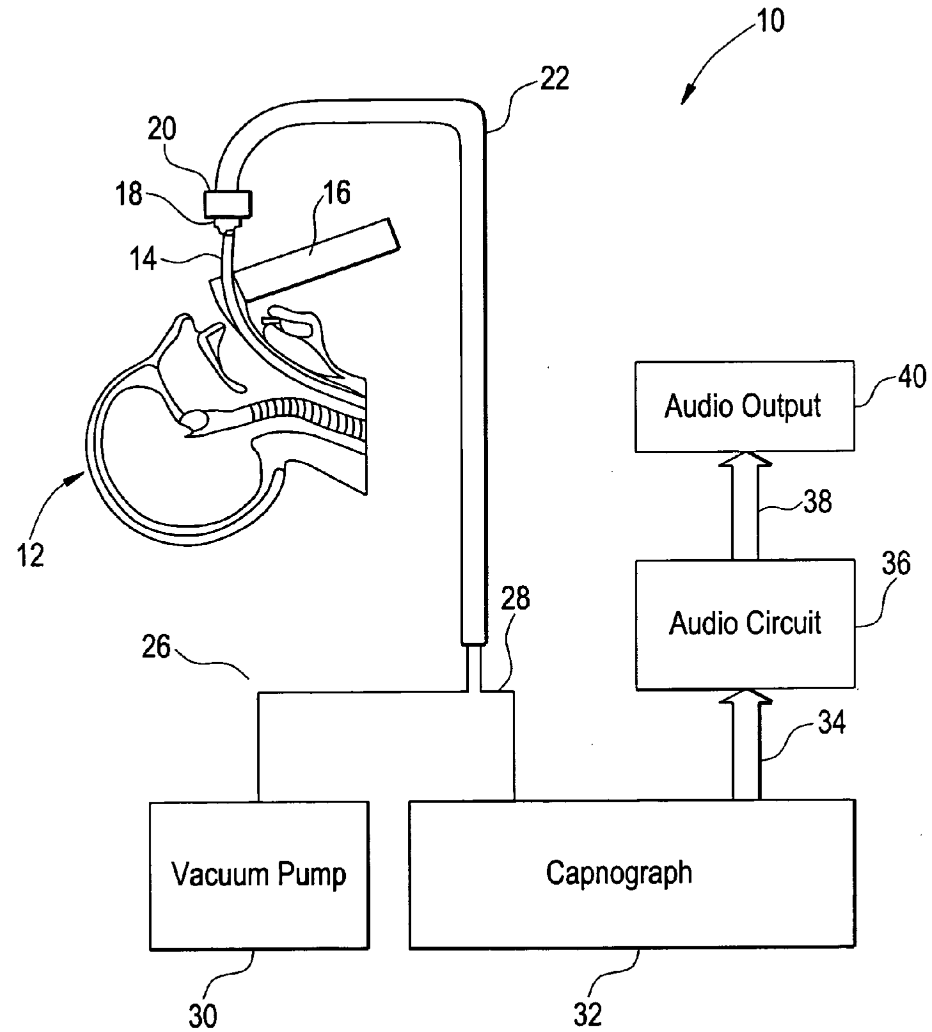


FIG. 1

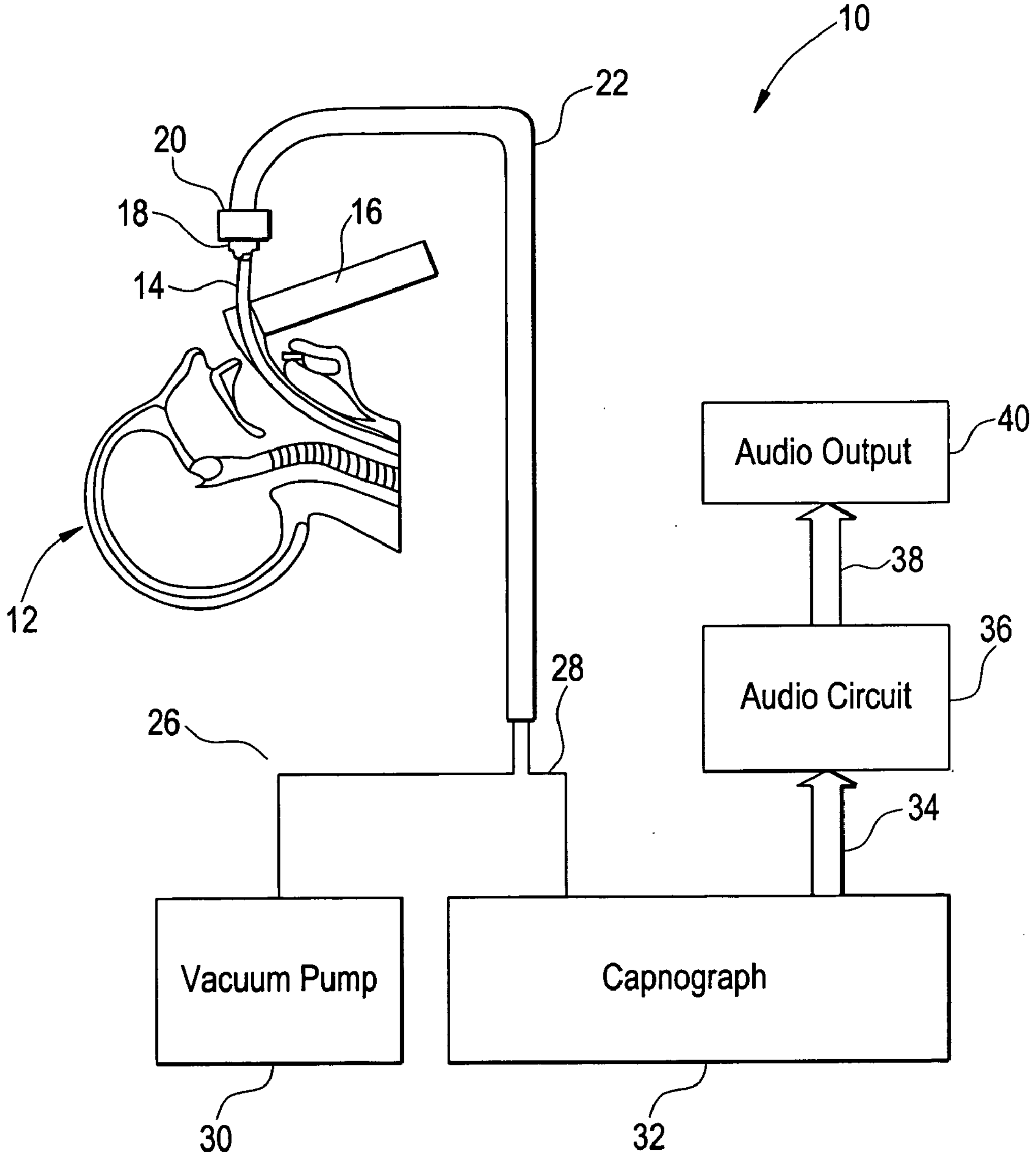

10
22
20
18
16
14
12
40
Audio Output
38
36
Audio Circuit
28
26
34
Vacuum Pump
Capnograph
30
32

FIG. 2

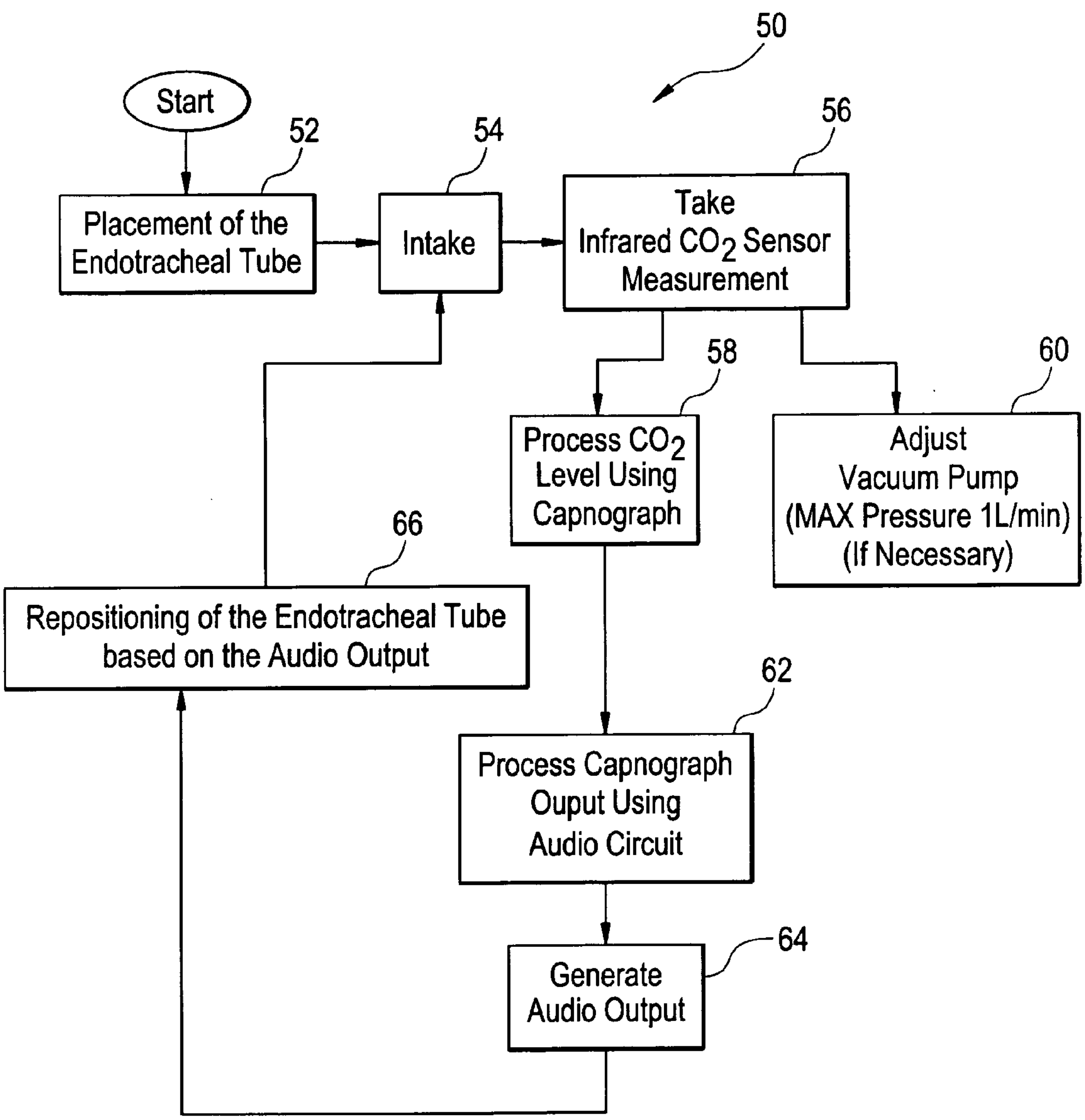

50
Start
52
Placement of the Endotracheal Tube
54
Intake
56
Take Infrared CO_2 Sensor Measurement
58
Process CO_2 Level Using Capnograph
60
Adjust Vacuum Pump (MAX Pressure 1L/min) (If Necessary)
66
Repositioning of the Endotracheal Tube based on the Audio Output
62
Process Capnograph Ouput Using Audio Circuit
64
Generate Audio Output

FIG. 3

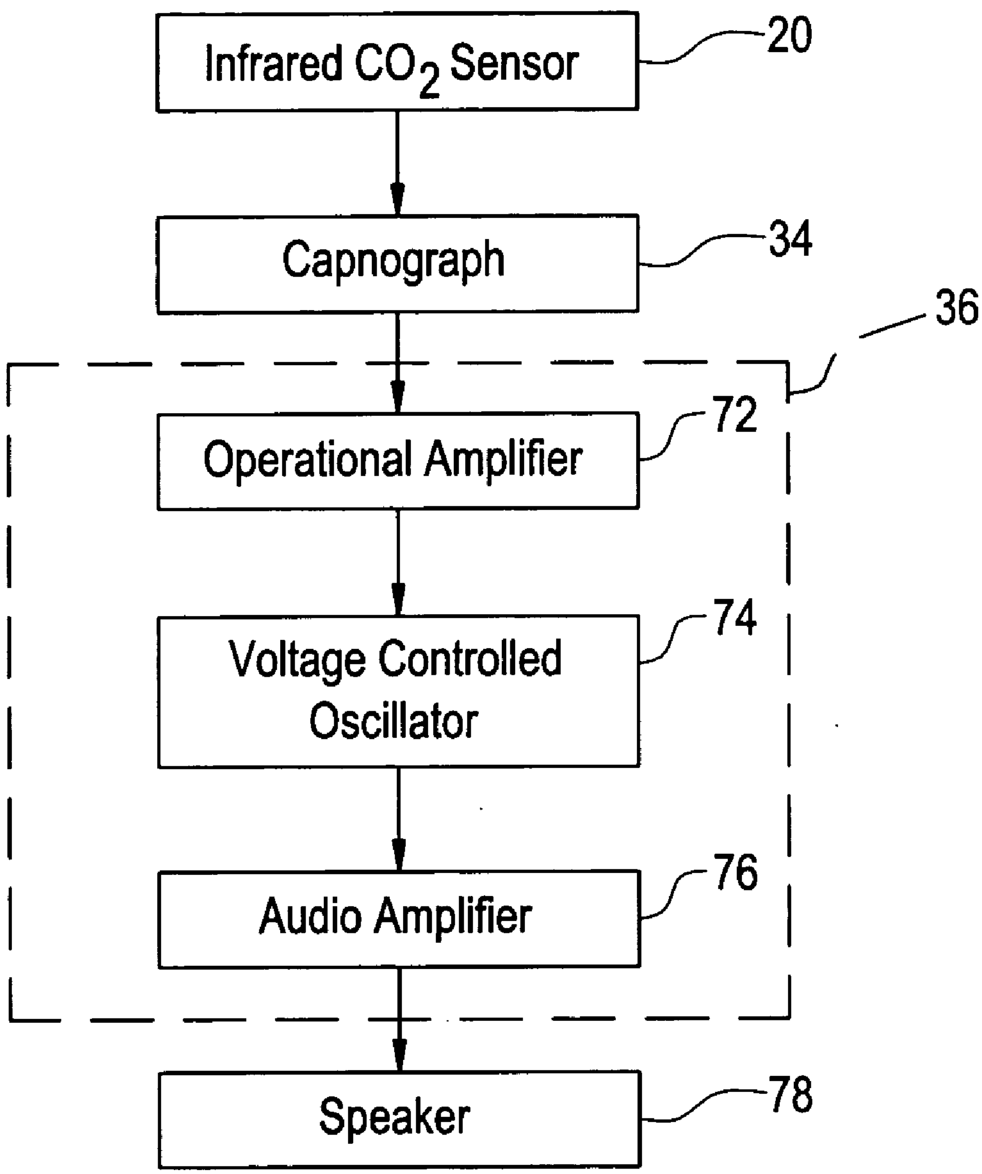

Infrared CO2 Sensor
20
Capnograph
34
36
Operational Amplifier
72
Voltage Controlled Oscillator
74
Audio Amplifier
76
Speaker
78

FIG. 4

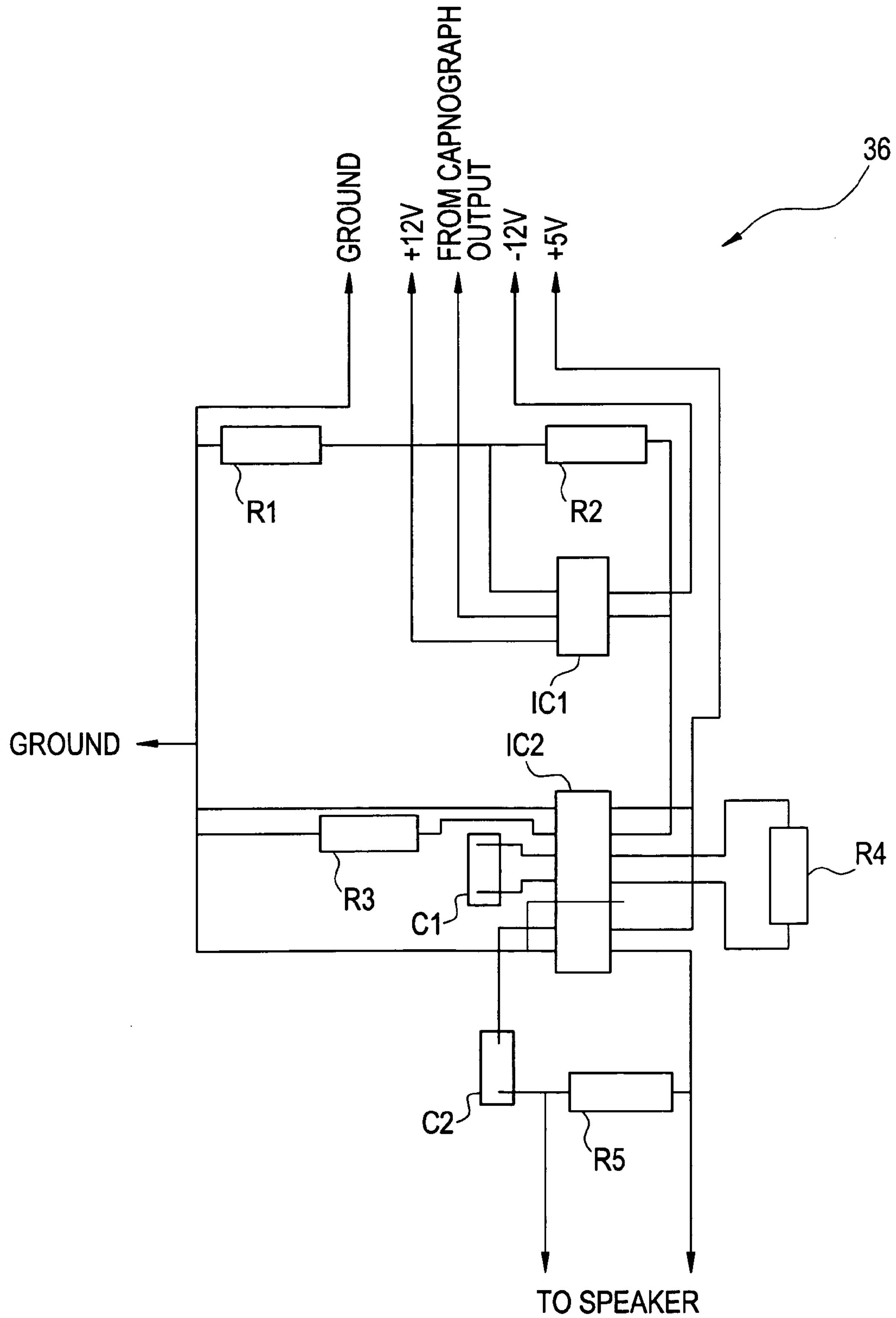

36
GROUND
+12V
FROM CAPNOGRAPH OUTPUT
-12V
+5V
R1
R2
IC1
GROUND
IC2
R3
C1
R4
C2
R5
TO SPEAKER

FIG. 5

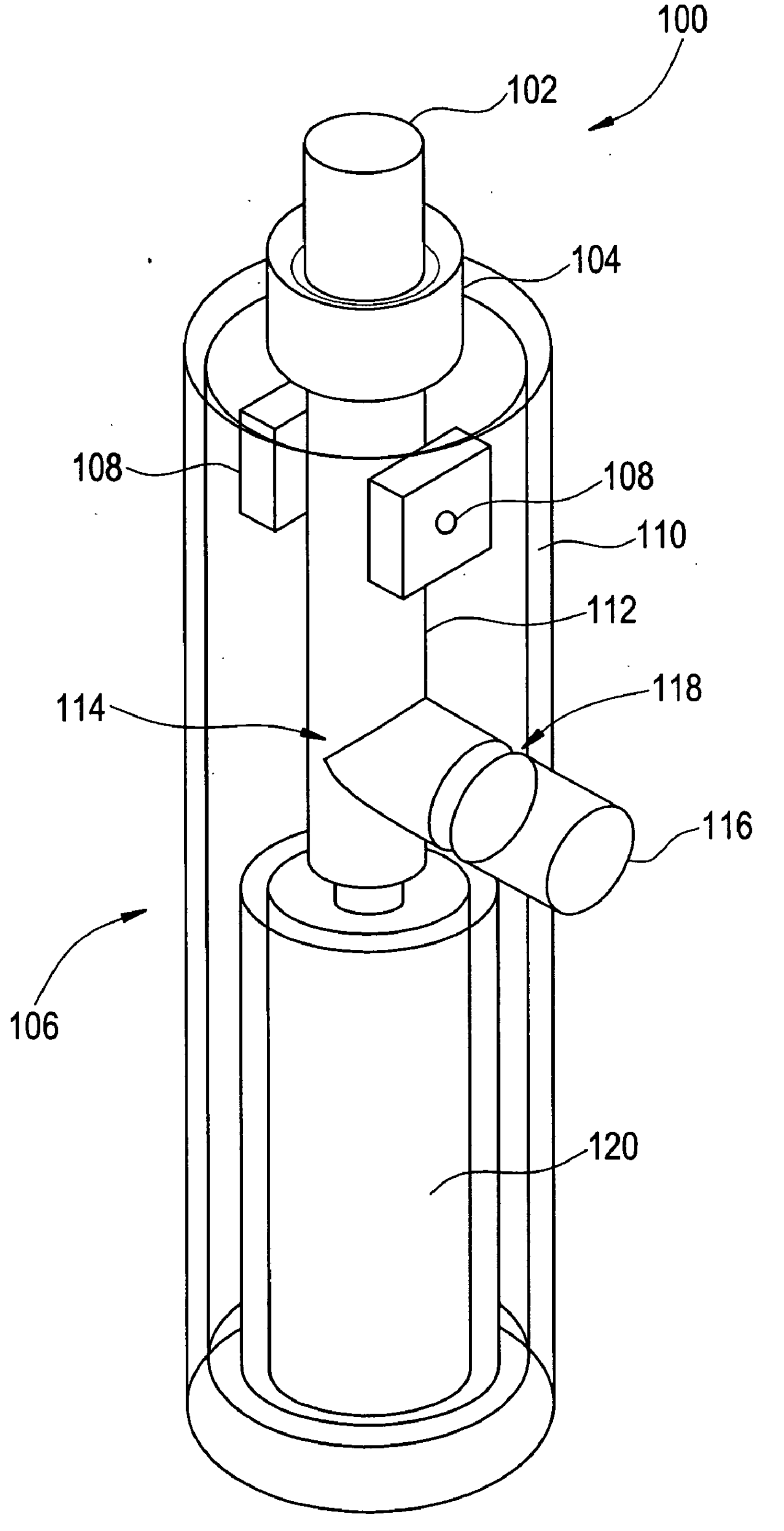
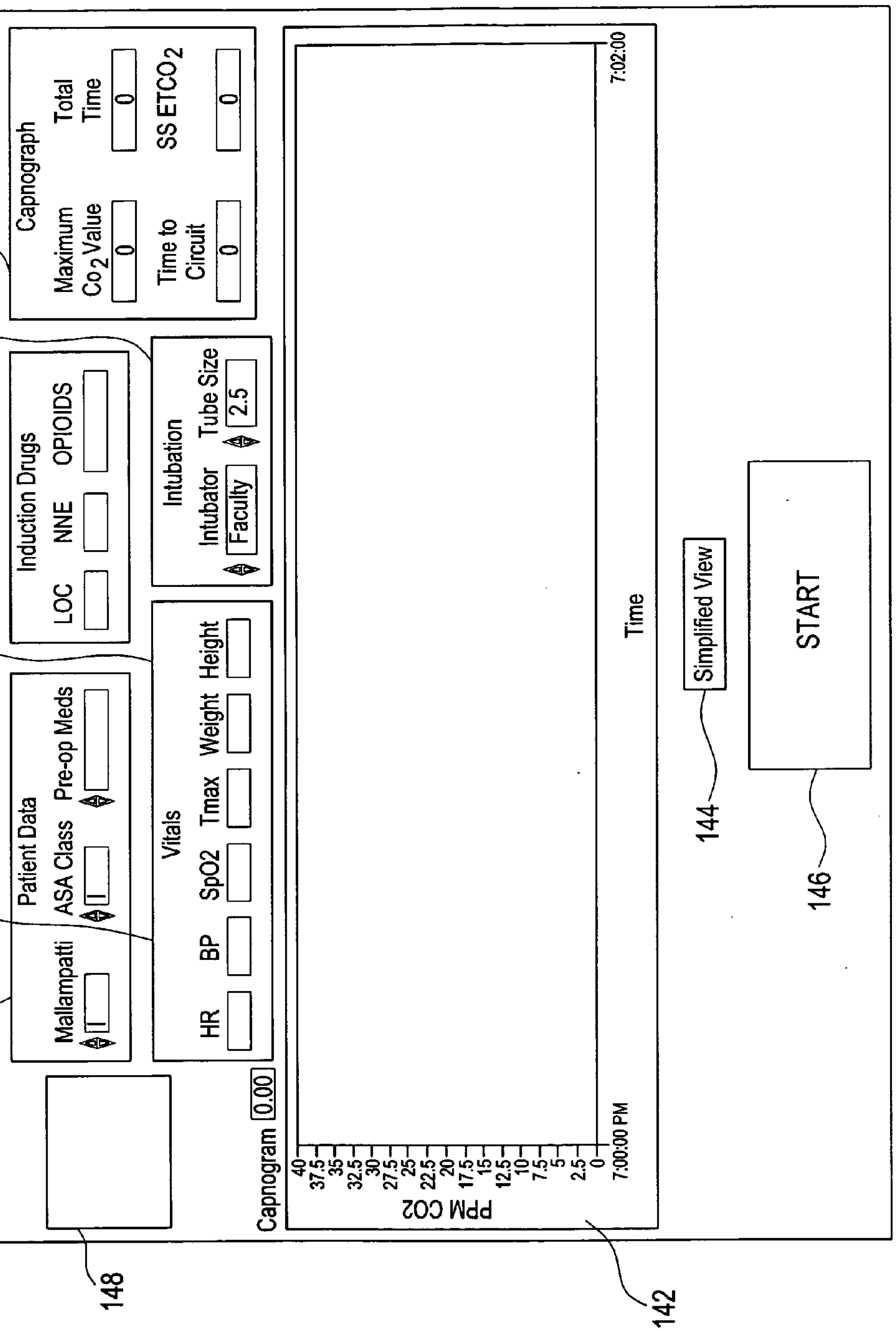


FIG. 6


130
136
Capnograph
Maximum
Co_2 Value
0
Total
Time
0
Time to
Circuit
0
SS $ETCO_2$
0
138
134
Induction Drugs
LOC
NNE
OPIOIDS
Intubation
Intubator
Faculty
Tube Size
2.5
140
139
132
Patient Data
Mallampatti
I
ASA Class
I
Pre-op Meds
Vitals
HR
BP
SpO2
Tmax
Weight
Height
Capnogram
0.00
PPM CO2
40
37.5
35
32.5
30
27.5
25
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
7:00:00 PM
7:02:00
Time
Simplified View
144
START
146
148
142

METHOD AND APPARATUS FOR CAPNOGRAPHY-GUIDED INTUBATION

RELATED APPLICATIONS

[0001] The present application claims the benefit under 35 U.S.C. § 119 of U.S. Provisional Application No. 60/856,109, filed Nov. 2, 2006, the contents of which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a device for ensuring proper intubation of a patent. More specifically, the present invention relates to a method and apparatus for capnography-guided intubation, where an auxiliary sensory indicator is included to assist therewith.

[0004] 2. Related Art

[0005] Intubation is an important medical procedure for ensuring that a patient with a blocked airway is able to breath. Frequently, intubation is practiced by inserting an endotracheal tube into the trachea of a patient, often with the assistance of a laryngoscope. Once inserted, the endotracheal tube can be connected to life support equipment, such as a respirator, to provide oxygen to the patient. In orotracheal intubation, the endotracheal tube is inserted into the mouth of the patient, guided past the larynx, and placed into the trachea. In nasotracheal intubation, a tube is inserted through a nostril of a patient and guided down to the trachea for placement therein. Still further, tracheal intubation involves a surgical incision into the trachea (tracheotomy), followed by insertion of a tube into the incision and placement of the tube in the trachea.

[0006] In each of the foregoing types of intubation, it can be difficult to properly guide the tube into the trachea of the patient, due to anatomical variations of the patient or abnormalities of larynx, trachea, or surrounding structures. Further, proper placement of the tube can be difficult due to injuries or diseases, such as gunshot wounds or tumors. Moreover, there always exist the dangers that vital anatomical structures can be damaged during the intubation process, or that the tube can be inadvertently inserted into the esophagus rather than the trachea. As such, there is a need to guide the intubation process to avoid these dangers.

[0007] Capnography is a known technique for use in the intubation process. Using capnography, carbon dioxide levels can be measured during intubation. Such levels provide an accurate indication of whether the endotracheal tube is properly guided into the patient's trachea. Low carbon dioxide levels (<5 mmHg) provide an indication that the endotracheal tube is not properly placed into the patient's trachea. Conversely, high carbon dioxide levels (>5 mmHg) provide an indication that the endotracheal tube is properly placed into the trachea.

[0008] A particular problem with existing, capnography-guided intubation techniques is that the user is not provided with a simple, easy to interpret indication of carbon dioxide levels, in real time. For example, while a capnograph can provide a visual indication (e.g., on a display panel) of carbon dioxide levels, the operator is forced to draw his or her attention away from the intubation process to view and interpret the carbon dioxide readings. This increases the danger of hurting the patient and prolonging the intubation process. Moreover, it is inconvenient and impractical to review numerical indications of carbon dioxide levels and to interpret same to determine whether intubation is occurring properly. Still further, in most intubation applications, capnographs are only used to confirm proper intubation after the procedure is complete. In such circumstances, if the intubation is not proper, the entire endotracheal tube must be removed and the intubation process repeated, thus increasing the possibility of injury to the patent as well as initiating asphyxia, which could cause brain injury or death if the intubation is not quickly corrected.

[0009] Accordingly, what would be desirable, but has not yet been provided, is a method and apparatus for capnography-guided intubation which solves the foregoing shortcomings of existing intubation techniques.

SUMMARY OF THE INVENTION

[0010] The present invention relates to a method and apparatus for capnography-guided intubation. The apparatus includes a conventional endotracheal tube or stylet for intubating a patient, a carbon dioxide sensor for measuring carbon dioxide levels during intubation of the patient, a vacuum pump connected to the endotracheal tube or stylet for drawing air from the patient's lungs and past the carbon dioxide sensor, a capnograph connected to the carbon dioxide sensor for measuring carbon dioxide levels, and an auxiliary sensor for the transmission and reception of a qualitative signal, such as a flashing light, a vibration signal or an audible signal indicative of carbon dioxide levels, in real time, during intubation of the patient. In a particular embodiment, the auxiliary sensor may comprise an audio circuit and associated audio output device for generating such audible signal. The auxiliary sensor provides an instant, easy-to-interpret, qualitative indication of carbon dioxide levels to guide the intubation process and to confirm proper placement of the endotracheal tube into the trachea of the patient. The apparatus could be provided in a single, portable housing that can be easily transported to a patient's location. Alternatively, all or a portion of the components of the apparatus could be provided in a handheld unit. For example, a handheld device could include an integral vacuum pump and carbon dioxide sensors, and could be connected to an endotracheal tube or stylet as well as to an external capnograph and an alarm, that may be visually omnidirectional, vibratory or audible. A graphical user interface is provided for displaying real-time carbon dioxide levels measured by the present invention, as well as for storing patient-related information.

[0011] Accordingly as a first aspect of the present invention, there is a system for determining the location of a intubation device in a patient, the system comprising a vacuum system for withdrawing gas from a patient through an intubation device, a sensing system for sensing the level of carbon dioxide in the withdrawn gas by the vacuum system and to provide a signal indicative of the level of carbon dioxide, and an auxiliary sensor for transmitting a qualitative sensory signal that is indicative of the level of carbon dioxide in the gas withdrawn by the vacuum system. The qualitative sensory signal may comprise an omnidirectional light signal such as a flashing light, a palpable vibratory signal, or an audio signal. In the instance of the last mentioned signal, an audio system can be included that is adapted to convert the signal from the sensing system into the audible sound.

[0012] In a further aspect, the system includes a carbon dioxide sensor located proximate to an intubation device that produces a signal indicative of the level of carbon dioxide in the withdrawn gas and in another aspect, the system includes a capnograph adapted to receive the signal from the carbon dioxide sensor and to produce a voltage signal indicative of the level of carbon dioxide in the withdrawn gas.

[0013] In a still further aspect, the invention includes an auxiliary processer unit such as an audio circuit, that receives the voltage signal from the capnograph and converts that voltage signal to a qualitative signal or alarm, such as a vibration, a flashing light, or an audible sound, any or all of which may vary in frequency in accordance with the level of the voltage signal. Still another aspect is a vacuum system that comprises a vacuum pump.

[0014] As another aspect of the present invention, there is a handheld device for determining the intubation of a patient comprising an inlet and an outlet, and a duct communicating between the inlet and the outlet, a vacuum pump connected to the duct for drawing gas through the duct, a carbon dioxide sensor located proximate to the duct for monitoring the level of carbon dioxide in the gas passing through the duct and for providing a signal indicative of that sensed level of carbon dioxide. A still further aspect includes a valve for controlling the flow of gas through the outlet. As another aspect, the carbon dioxide sensor is an infrared sensor. Further yet, the inlet of the device comprises an adapter for connection to an intubation device. As a still further aspect, the device comprises an adapter for connection to an endotracheal tube.

[0015] In another aspect of the present invention, there is a system for determining the location of an intubation device within a patient comprising an intubation device having a distal end and a proximal end, a system for withdrawing gas through the intubation device from a location within the patient proximate to the distal end of the intubation device, a sensing system for sensing the level of carbon dioxide in the gas passing through the intubation device and providing a signal indicative of the level of the sensed carbon dioxide, the sensing system including an auxiliary sensor, such as an audio system, that receives the signal from the sensing system and converts that signal into a qualitative sensory signal such as an omni-directional light signal (e.g. a flashing light), a vibratory signal, or an audio signal indicative of the level of carbon dioxide in the gas withdrawn by the vacuum system. In a still further aspect, the system includes a vacuum pump. In another aspect, the intubation device is an endotracheal tube. Still further, the sensing system of the invention provides a voltage having a magnitude indicative of the level of sensed carbon dioxide and in the case of the audible sound signal, includes an audio circuit and audio output device that converts the voltage signal into such audible sound, that is indicative of the level of sensed carbon dioxide. Yet further, the audible sound has a frequency that is indicative of the level of sensed carbon dioxide.

[0016] In a still further aspect of the present invention there is a method of determining the location of an intubation device in a patient comprising the steps of;

[0017] (a) introducing an intubation device having a distal end and a proximal end into a patient,

[0018] (b) removing a sample of gas from the patient at a location proximate to the distal end of the intubation device;

[0019] (c) determining the carbon dioxide content of the sample of gas removed from the patient; and

[0020] (d) creating a qualitative sensory signal selected for the group consisting of an omnidirectional light signal, a vibratory signal or an audio signal indicative of the level of carbon dioxide determined in step (c).

[0021] In this aspect, and with respect to the audible signal, there further is included the step of creating an audible sound that comprises providing an electrical voltage that is indicative of the level of carbon dioxide determined in step (c) and converting the electrical voltage to an audible sound having a frequency indicative of the level of carbon dioxide determined in step (c).

[0022] In a further aspect, the step of introducing an intubation device into a patient includes the step of repositioning the intubation device based on the sensory signal created in step (d).

[0023] Still further there is an aspect wherein the step of determining the carbon dioxide content of the sample of gas removed from the patient comprises positioning a carbon dioxide sensor proximate to the proximal end of the intubation device.

[0024] Finally, as a still further aspect, the method includes the step of removing a sample of gas from the patient at a location proximate to the distal end of the intubation device comprises applying a vacuum to the intubation device to draw gas from the distal end of the intubation device.

[0025] Accordingly, it is a principal object of the present invention to provide a method for the capnography-assisted intubation of a patient which simplifies the management of the process and thereby reduces the possibility of error and harm to the patient.

[0026] It is a further object of the present invention to provide a system for use in the method as aforesaid, that introduces a sensory signal, such as an audible sound, as an indication of patient carbon dioxide level that does not require the diversion of attention from the intubation procedure.

[0027] It is a still further object of the invention to provide a method and system as aforesaid, where the sensory signal provides the indication in real time.

[0028] It is yet a further object of the invention to provide a system as aforesaid, which may comprise a hand held device for use in the present method.

[0029] Other objects and advantages will become apparent to those skilled in the art from a consideration of the ensuing detailed description taken in conjunction with the following illustrative drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] FIG. **1** is a diagram showing an audible, capnography-guided intubation apparatus constructed in accordance with a particular alternate embodiment of the present invention;

[0031] FIG. **2** is a flowchart showing a process for operating the apparatus of FIG. **1**;

[0032] FIG. **3** is a block diagram showing the audio circuit of the present invention in greater detail;

[0033] FIG. **4** is an electrical schematic of the audio circuit of the present invention;

[0034] FIG. **5** is a diagram showing a portable, handheld device according to the present invention for capnography-guided intubation; and

[0035] FIG. 6 is a screenshot of a graphical user interface screen according to the present invention for displaying real-time carbon dioxide levels and for storing and displaying patient-related information.

DETAILED DESCRIPTION OF THE INVENTION

[0036] The present invention relates to a method and apparatus for capnography-guided intubation. The present invention is operable with any suitable endotracheal tube or stylet, and includes a carbon dioxide sensor, a vacuum source for drawing air from the patient's lungs and past the carbon dioxide sensor, a capnograph, and an auxiliary sensor such as an audio circuit and associated audio output device. A sensory signal, such as an omnidirectional visual display or light, a vibratory signal, or an audible signal, is generated during intubation of a patient to provide an audible indication of carbon dioxide levels, so as to facilitate proper placement of an intubation tube. In the case of the audible signal, the frequency (pitch) corresponds to measured carbon dioxide levels, thereby providing a simple, easy-to-interpret, indication of the current position of an endotracheal tube during intubation, as well as confirmation of proper placement of the tube.

[0037] FIG. **1** is a diagram showing an apparatus **10** constructed in accordance with the present invention, for providing capnography-guided intubation of a human **12**. The apparatus **10** is operable with any conventional endotracheal tube, such as the endotracheal tube **14**, or a suitable stylet (hollow or solid). It has been found that endotracheal tubes with sizes of 7 to 9 mm are suitable, such as those sold by Hudson RCI, Inc. As is known in the art, a laryngoscope **16** can be used to facilitate insertion of the endotracheal tube **14** into the airway of the human **12**. The apparatus **10** includes an adapter **18** for allowing removable connection of the endotracheal tube **14** or a stylette thereto, a carbon dioxide (CO_2) sensor **20**, a reinforced tube **22** having an air tube **26** and an electrical cable **28** extending therethrough, a vacuum pump **30**, a capnograph **32**, and an auxiliary sensor means, illustrated by audio circuit **36**, that is connected to an audio output device **40** (e.g., a speaker). The air tube **26** establishes fluid communication between the endotracheal tube **14** and the vacuum pump **30**, and the electrical cable **28** establishes electrical communication between the sensor **20** and the capnograph **32**. A trap could be provided before the vacuum pump **30** to prevent fluids from the airway of the human **12** from damaging the pump **30**.

[0038] During intubation of the human **12**, the vacuum pump **30** is operated to draw air from the lungs of the human **12**, through the endotracheal tube **14**, and past the sensor **20**, so that carbon dioxide levels in the air can be measured by the sensor **20**. The vacuum pump **30** could include the B-series micro air pump (Model No. BP120CNNN) manufactured by Sensidyne, Inc., or any other suitable vacuum pump. The sensor **20** converts carbon dioxide levels into electrical signals which are processed by the capnograph **32**. It should be noted that the sensor **22** could be an infrared carbon dioxide sensor, or any other suitable type of sensor. The sensor **20** and the capnograph **32** could together comprise the CO_2SMO® Mainstream Capnograph/Pulse Oximeter manufactured by Respironics, Inc., or any other suitable capnography equipment. The capnograph **32** generates an electrical signal **34** corresponding to the level of carbon dioxide sensed by the sensor **20**. The voltage level of the signal **34** varies based upon the level of carbon dioxide sensed by the sensor **20**.

[0039] In the illustrated embodiment, the signal **34** is processed by an audio circuit **36**, generating an audio signal **38** that can be sent to an audio output device **40**, such as a speaker. The audio circuit **36** converts changes in the voltage level of the signal **34** to changes in the frequency (pitch) of the audio signal **38**. An increase in the pitch of the audio signal **38** indicates an increase in the concentration of carbon dioxide, thereby providing an indication to the operator that the endotracheal tube **14** has entered into the trachea **12** of the human, or is properly placed therein. As indicated however, other sensor means and assemblies, not illustrated herein, could be used to perform the same function. Thus, for example, signal **34** could be directed to a circuit that would activate an omnidirectional light source, that by its illumination, would provide a like indication of modulation in carbon dioxide levels. Similarly, the output signal could activate a generator of vibratory energy that would provide a like indication to the medical personnel and would thereby warn of fluctuations in carbon dioxide levels. As the invention contemplates and extends to other sensory signal means and corresponding systems, all such variations are intended to be embraced herein, and are considered within the scope hereof, so that the detailed discussion of the audio circuit is illustrative and not restrictive of the claimed invention.

[0040] It should be noted that the vacuum pump **30**, the capnograph **32**, the audio circuit **36**, and the audio output device **40** could be provided in a single, portable enclosure that can be easily transported to a patient's bedside, to an operating room, or to any other desired location. Further, the present invention could be maintained in an ambulance or rescue vehicle, and easily transported to an emergency location. Additionally, the apparatus **10** could be battery-powered, or a standard, 120 volt alternating current (AC) power supply could be utilized. Any desired configuration of the components of the apparatus **10** could be provided without departing from the spirit or scope of the present invention.

[0041] FIG. **2** is a flowchart of a process, indicated generally at **50**, for operating the apparatus **10** of FIG. **1**. Beginning in step **52**, the endotracheal tube **14** of FIG. **1** is placed into the mouth of a patient, and intubation is initiated. In step **54**, the vacuum pump **30** of FIG. **1** is operated to draw (intake) air from the patient's lungs into the endotracheal tube and past the carbon dioxide sensor **20** of FIG. **1**. In step **56**, a carbon dioxide measurement is taken by the sensor **20**, and in step **58**, the measurement is processed by the capnograph **32** of FIG. **1** to generate an electrical signal corresponding to measured carbon dioxide levels. Optionally, in step **60**, the vacuum pump **30** of FIG. **1** could be adjusted to provide a desired airflow rate (e.g., up to a maximum of 1 liter per minute). In step **62**, the output (electrical signal) generated by the capnograph **62** is processed by the audio circuit **36** of FIG. **1**.

[0042] In step **64**, an audio signal is generated by the audio circuit **36** of FIG. **1**, based upon the electrical signal generated by the capnograph. During initial intubation of the patient (e.g., after inserting the endotracheal tube into the mouth of the patient), carbon dioxide levels are low. As a result, the frequency of the audio signal will be low, thereby indicating to the user that the endotracheal tube **14** of FIG. **1** is not positioned within the airway of the patient. In step **66**, the endotracheal tube **14** of FIG. **1** could be repositioned as desired, based upon the frequency of the audio signal. The process **50** is repeated during intubation of the patient, thereby providing an audible indication of carbon dioxide levels in real time. As the endotracheal tube of FIG. **1** is inserted into the trachea, carbon dioxide levels rise, thereby resulting in an increase in the frequency of the audio signal generated by the present invention. Such an increase provides an audible indication to the operator that the endotracheal tube is being properly inserted into the trachea, or confirmation that intubation is complete.

[0043] FIG. **3** is a block diagram showing the audio circuit **36** of FIG. **1** in greater detail. As mentioned earlier, the sensor **20** is connected to the capnograph **34** to generate an electrical signal indicative of sensed carbon dioxide levels in real time during intubation of the patient. The audio circuit **36** converts this electrical signal into an audio signal, which provides an audible indication of carbon dioxide levels. The audio circuit **36** includes an operation amplifier **72** for amplifying the electrical signal generated by the capnograph **34**, a voltage-controlled oscillator (VCO) **74** for generating an audible signal having a frequency that is adjustable based upon the voltage of the electrical signal amplified by the operational amplifier **72**, and an audio amplifier **76** for amplifying the audio signal. The audio signal can drive a speaker **78**, or it can be transmitted to another device.

[0044] FIG. **4** is an electrical schematic of the audio circuit **36** of FIG. **1**. The circuit **36** is connected to electrical ground, direct current (DC) sources of +12 V, −12 V, and +5V, and the electrical output of the capnograph **32** of FIG. **1**. The circuit **36** can also be connected to drive a speaker or suitable type of audio output device. The circuit **36** includes integrated circuit IC**1**, which corresponds to the operational amplifier **72** of FIG. **3**. IC**1** could include the LM741CN operational amplifier manufactured by National Semiconductor, Inc., or any other suitable operational amplifier. The circuit **36** also includes integrated circuit IC**2**, which corresponds to the VCO **74** of FIG. **3**. IC**2** could include the SN54LS624 VCO manufactured by Texas Instruments, Inc., or any other suitable VCO. A plurality of discrete components is also included in the circuit **36**, including resistors R**1**-R**5** and capacitors C**1**-C**2**. The associated values for these components are given in the following table:

TABLE 1

Component	Value
R1	5,000 Ohms
R2	1,000 Ohms
R3	5,000 Ohms
R4	500 Ohms
R5	5,000 Ohms
C1	47 microFarads
C2	100 microFarads

[0045] It should be noted that the capacitor C**2** and the resistor R**5** are not required to operate the circuit **36**, but are useful for filtering the audio signal. The circuit **36** can generate an audio signal in the audible range of 20 Hz to 20 kHz. As indicated previously, low audio frequencies correspond to low carbon dioxide levels (indicating that the endotracheal tube is not in the patient's airway) and high audio frequencies correspond to high carbon dioxide levels (indicating proper placement of the endotracheal tube in the patient's airway).

[0046] FIG. **5** is a perspective view of a handheld device **100** according to the present invention for monitoring carbon dioxide levels during intubation. The device **100** includes an adaptor **104** for allowing removable attachment of input tubing **102** (e.g., an endotracheal tube or a stylette) and a handheld portion **106** including a housing **110**, a plurality of infrared carbon dioxide detectors **108**, a duct **112**, a valve **114**, an exhaust tube **116** extending through an aperture **118** in the housing **110**, and a vacuum pump **120**. During intubation, the valve **114** (which could be manually-operated or electronic) and the vacuum pump **120** are operated to draw air through the tubing **102**, past the infrared detectors **108**, through the duct **112**, and to vent same through the exhaust tubing **116**. The infrared detectors **108** monitor carbon dioxide levels during intubation, in the manner described herein, and are in electrical communication with a capnograph and the audio circuit of the present invention to provide an audible signal indicative of carbon dioxide levels. It should be noted that the device **100** could also include an internal battery for powering same, or it could be connected to an external (e.g., 120 volt AC) power supply.

[0047] FIG. **6** is a screenshot showing a graphical user interface **130** according to the present invention for displaying patient data and carbon dioxide levels during intubation of a patient. The interface **130** could execute on any suitable computer system connected to the capnograph of the present invention, such as a personal computer, a workstation, or a portable computing device (e.g., a personal digital assistant (PDA), pocket computer, or the like). The interface **130** could be coded using any suitable programming language known in the art, such as Java or C++. Further, the interface **130** could be linked to a relational database management system (DBMS) for storing and accessing patient-related data.

[0048] The interface **130** includes data fields **132** for entering patient data. Data fields **134** allow for the entry of information relating to induction drugs. Information about the capnograph could be entered in fields **136**, and intubation information can be entered in fields **138**. Vital statistics about the patient could be entered in fields **139**. A graph area **142** displays real-time carbon dioxide levels measured during intubation. A button **144** can be clicked by a user to display a simplified view, i.e., a view containing less information than described above. Start and stop buttons **146** and **148** can be clicked as desired to start and stop the capturing of carbon dioxide level information.

[0049] As stated above in respect to the sensory indicator component of the invention, it should be noted that the present invention could be modified to provide other types of indications of carbon dioxide levels, in real time, such as visual, tactile, or other indications. For example, a light could be provided and modulated (e.g., flashed at different rates) to indicated various carbon dioxide levels, or an array of lights (e.g., a light-emitting diode (LED) array) could be provided for displaying such levels. Moreover, any suitable type of display, such as an LED display, liquid crystal display (LCD), flat panel display, cathode ray tube (CRT), or other types of displays, could be used to indicate carbon dioxide levels. Other types of indicators, such as tactile signals, could also be implemented. For example, the present invention could include a vibration source which vibrates across a span of frequencies to indicate various carbon dioxide levels. Thus, as will be readily appreciated, the present invention could be modified to provide any desired type of sensory indication of carbon dioxide levels.

[0050] Having thus described the invention in detail, it is to be understood that the foregoing description is not intended to limit the spirit or scope thereof.

What is claimed is:

1. A system for determining the location of a intubation device in a patient, the system comprising: a vacuum system for withdrawing gas from a patient through an intubation device, a sensing system for sensing the level of carbon dioxide in the withdrawn gas by the vacuum system and to provide a signal indicative of the level of carbon dioxide, an auxiliary sensor adapted to convert the signal from the sensing system into a qualitative sensory signal selected from the group consisting of an omnidirectional light signal, a vibratory signal or an audio signal indicative of the level of carbon dioxide in the gas withdrawn by the vacuum system.

2. The system as defined in claim **1** wherein the sensing system includes a carbon dioxide sensor located proximate to an intubation device that produces a signal indicative of the level of carbon dioxide in the withdrawn gas.

3. The system of claim **2** wherein the sensing system further includes a capnograph adapted to receive the signal from the carbon dioxide sensor and to produce a voltage signal indicative of the level of carbon dioxide in the withdrawn gas.

4. The system of claim **3** wherein the auxiliary sensor includes an audio circuit that receives the voltage signal from the capnograph and converts that voltage signal to an audible sound that varies in frequency in accordance with the level of the voltage signal.

5. The system of claim **3** wherein the vacuum system comprises a vacuum pump.

6. A handheld device for determining the intubation of a patient comprising an inlet and an outlet, and a duct communicating between the inlet and the outlet, a vacuum pump connected to the duct for drawing gas through the duct, a carbon dioxide sensor located proximate to the duct for monitoring the level of carbon dioxide in the gas passing through the duct and for providing a signal indicative of that sensed level of carbon dioxide.

7. The handheld device as defined in claim **6** wherein the device further includes a valve for controlling the flow of gas through the outlet.

8. The handheld device as defined in claim **6** wherein the carbon dioxide sensor is an infrared sensor.

9. The hand held device as defined in claim **6** wherein the inlet comprises an adapter for connection to an intubation device.

10. The hand held device as defined in claim **6** wherein the inlet comprises an adapter for connection to an endotracheal tube.

11. A system for determining the location of an intubation device within a patient comprising;

an intubation device having a distal end and a proximal end;

a system for withdrawing gas through the intubation device from a location within the patient proximate to the distal end of the intubation device,

a sensing system for sensing the level of carbon dioxide in the gas passing through the intubation device and providing a signal indicative of the level of the sensed carbon dioxide;

an auxiliary sensor receiving the signal from the sensing system and converting that signal into a qualitative sensory signal selected from the group consisting of an omnidirectional light signal, a vibratory signal or an audio signal indicative of the level of carbon dioxide in the gas withdrawn by the vacuum system.

12. The system of claim **11** wherein the system for withdrawing gas comprises a vacuum system using a vacuum pump.

13. The system of claim **11** wherein the intubation device is an endotracheal tube.

14. The system of claim **11** wherein the sensing system provides a voltage having a magnitude indicative of the level of sensed carbon dioxide and the auxiliary sensor includes an audio circuit and audio output device that converts the voltage signal into an audible sound that is indicative of the level of sensed carbon dioxide.

15. The system of claim **14** wherein the audible sound has a frequency that is indicative of the level of sensed carbon dioxide.

16. A method of determining the location of an intubation device in a patient comprising the steps of;

(a) introducing an intubation device having a distal end and a proximal end into a patient,

(b) removing a sample of gas from the patient at a location proximate to the distal end of the intubation device;

(c) determining the carbon dioxide content of the sample of gas removed from the patient; and

(d) creating a qualitative sensory signal selected from the group consisting of an omnidirectional light signal, a vibratory signal or an audio signal indicative of the level of carbon dioxide determined in step (c).

17. The method of claim **16** wherein the step of creating a qualitative sensory signal comprises providing an electrical voltage that is indicative of the level of carbon dioxide determined in step (c) and converting the electrical voltage to an audible sound having a frequency indicative of the level of carbon dioxide determined in step (c).

18. The method of claim **16** wherein the step of introducing an intubation device into a patient includes the step of repositioning the intubation device based on the qualitative sensor signal created in step (d).

19. The method of claim **16** wherein the step of determining the carbon dioxide content of the sample of gas removed from the patient comprises positioning a carbon dioxide sensor proximate to the proximal end of the intubation device.

20. The method of claim **16** wherein the step of removing a sample of gas from the patient at a location proximate to the distal end of the intubation device comprises applying a vacuum to the intubation device to draw gas from the distal end of the intubation device.

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