(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 September 2005 (01.09.2005)

PCT

(10) International Publication Number
WO 2005/079897 A1

(51) International Patent Classification[7]: A61M 16/00

(21) International Application Number:
PCT/AU2005/000248

(22) International Filing Date: 24 February 2005 (24.02.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/547,812 25 February 2004 (25.02.2004) US

(71) Applicant *(for all designated States except US)*: **RESMED LIMITED** [AU/AU]; 97 Waterloo Road, North Ryde, New South Wales 2113 (AU).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **PHUAH, Chee, Keong** [MY/AU]; c/-ResMed Limited, 97 Waterloo Road, North Ryde, New South Wales 2113 (AU). **FARRUGIA, Steven, Paul** [AU/AU]; c/- ResMed Limited, 97 Waterloo Road, North Ryde, New South Wales 2113 (AU). **MARTIN, Dion, Charles, Chewe** [AU/AU]; c/- ResMed Limited, 97 Waterloo Road, North Ryde, New South Wales 2113 (AU). **CHAN, Christine, Wei, Chih** [AU/AU]; 43 Newton Road, Strathfield, New South Wales 2135 (AU).

(74) Agents: **DAVIDSON, Geoffrey, Robert** et al.; Halford & Co., 1 Market Street, Sydney, New South Wales 2000 (AU).

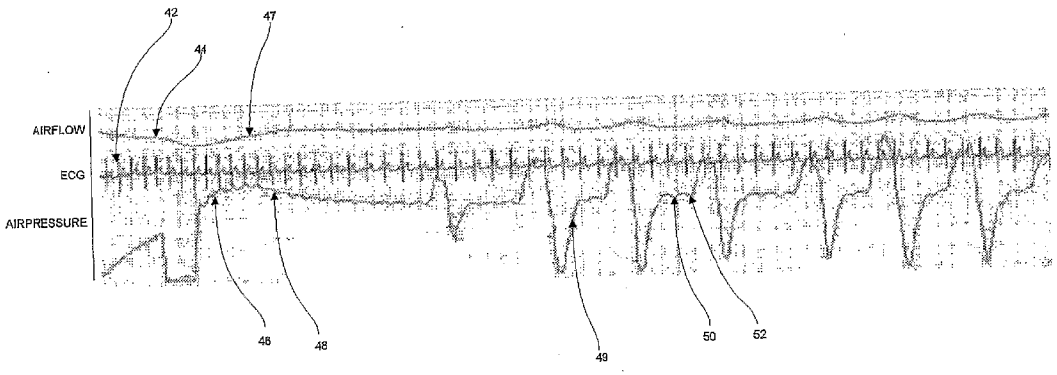
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: CARDIAC MONITORING AND THERAPY USING A DEVICE FOR PROVIDING PRESSURE TREATMENT OF SLEEP DISORDERED BREATHING



(57) Abstract: A method of using CPAP equipment to sense cardiogenic oscillations in a patient's airflow, and to monitor and treat the patient's cardiac condition. The apparatus diagnoses cardiac morbidity conditions, such as the existence of arrhythmias or other cardiac abnormalities, and influences and optimizes cardiac stroke volume. The apparatus further monitors pulse-transit time, changes in the heart pre-ejection period, and the duration of the cardiac cycle.

WO 2005/079897 A1

CARDIAC MONITORING AND THERAPY USING A DEVICE FOR PROVIDING PRESSURE TREATMENT OF SLEEP DISORDERED BREATHING

Field of the Invention

[0001] This application claims the priority of U.S. provisional application Serial No. 60/547,812 filed on February 25, 2004. This invention relates to a method and apparatus for detecting cardiac signals in a CPAP patient's airflow and using the signals to monitor and treat cardiac conditions.

Background of the Invention

[0002] Cessation of breathing during sleep for more than 10 seconds is called an "apnea," which leads to decreased blood oxygenation and disruption of sleep. Apneas are traditionally categorized as central, where there is no respiratory effort, or obstructive sleep apnea (OSA), where there is respiratory effort but the airway is blocked. With purely central apneas, the airway is patent (or open), but the patient is not attempting to breathe. With other central apneas and all obstructive apneas, the airway is not patent (i.e., it is occluded). The occlusion is usually at the level of the tongue or soft palate.

[0003] The common form of treatment of apneas is the administering of continuous or variable positive airway pressure (referred to herein generally as CPAP). Devices that provide CPAP treatment are described in U.S. Patent Nos. 5,704,345, 6,532,957, 6,575,163, 6,484,719, 6,688,307, and 6,532,959, incorporated herein by reference. The procedure for administering CPAP treatment has been well documented in both the technical and patent literature. Briefly stated, CPAP treatment acts as a pneumatic splint of the airway by the provision of positive pressure, usually in the range 4-20 cm H_2O. The air is supplied to the airway by a motor driven blower whose outlet passes air via a delivery tube or hose to a nose (and/or mouth) mask sealingly engaged to a patient's face. An exhaust port is provided in the delivery tube proximate to the mask.

More sophisticated forms of CPAP, such as bi-level CPAP and self-titrating CPAP, are described in U.S. Patent Nos. 5,148,802 and 5,245,995, respectively.

[0004] CPAP therapy is also known to be beneficial to some cardiac pathology, for example, congestive heart failure. By boosting intrathoracic pressure, CPAP offers various (potential) direct benefits in heart failure, for example, impeding venous return (reducing preload), reducing the systolic pressure gradient against which the left ventricle must pump (reduced afterload), and reducing left-ventricular trans-mural pressure (improved contractile efficiency). In addition, CPAP may offer indirect benefits to heart-failure patients, e.g., to counter pulmonary edema, to increase lung volume (may aid ventilatory stability in Cheyne-Stokes respiration), and in patients with a disposition to obstructive apnea, to reduce sympathetic activation through prevention of repetitive OSA.

[0005] Various techniques are known for detecting abnormal breathing patterns indicative of obstructed breathing. U.S. Patent No. 5,245,995, for example, describes how snoring and abnormal breathing patterns can be detected by inspiration and expiration pressure measurements while sleeping, thereby leading to early indication of pre-obstructive episodes or other forms of breathing disorder. Patterns of respiratory parameters are monitored, and CPAP pressure is raised on the detection of pre-defined patterns to provide increased airway pressure to subvert the occurrence of the obstructive episodes and the other forms of breathing disorder.

[0006] Central apneas need not involve an obstruction of the airway, and often occur during very light sleep and in patients with various cardiac, cerebrovascular and endocrine conditions unrelated to the state of the upper airway. In cases where the apnea is occurring without obstruction of the airway, there may be little benefit in increasing CPAP pressure, in contrast to an obstructive apnea.

[0007] To differentiate between central and obstructed apneas, U.S. Patent No. 6,029,665, incorporated herein by reference, teaches a CPAP system that monitors

pulsatile airflow during the apnea event. With each beat of the heart, of the order of 66 ml of blood is ejected from the chest over about 0.3 sec, producing a pulsatile blood flow out of the chest of the order of 0.22 l/sec peak flow. If the chest wall were rigid this would create a partial vacuum in the chest cavity, and, if the upper airway were open and had zero flow resistance, a similar quantity of air would be sucked in through the trachea. In practice, the chest wall is not totally rigid, and the airways have finite airflow resistance. Consequently the measurable airflow (or cardiogenic oscillation) with each beat of the heart is of the order of 0.02 to 0.1 l/sec.

[0008] If there is a central apnea with an open airway, the device of the '665 patent will sense cardiogenic oscillations in the air pressure, and determine that an unobstructed central apnea event has occurred. Conversely, if the airway is closed, the pressure waveform will not have any noticeable cardiogenic oscillations, and the device of the '665 patent will determine that the apnea event was an obstructed event.

[0009] Implementing the apparatus and method of the '665 patent prevents the inappropriate increase in the splinting CPAP air pressure during a central apnea, thereby preventing an unnecessary increase in pressure that may otherwise reflexively inhibit breathing and further aggravate the breathing disorder. The device is also used in a diagnostic mode, using nasal cannulae in the place of a face mask, where measurements of apneas, patency, and partial obstruction are logged, but no CPAP treatment is effected. The data provides a physician with the ability to diagnose conditions such as OSA and upper airway resistance syndrome.

[0010] Neither the '665 patent nor other prior art utilizes measurements of cardiogenic oscillations in a CPAP patient's airflow for monitoring or treating conditions related to cardiac health.

Objects and Summary of the Invention

[0011] It is an object of the invention to utilize a CPAP device that treats sleep disordered breathing (SDB) also as a cardiac treatment device by monitoring cardiac signals in a patient's airflow to determine cardiac health.

[0012] More specifically, it is an object of the invention to monitor the cardiac signals to screen and diagnose cardiac morbidity conditions, such as the existence of arrhythmias, and to influence and optimize cardiac stroke volume.

[0013] It is a further object to monitor pulse-transit time, changes in the heart pre-ejection period, and the duration of the cardiac cycle.

[0014] To satisfy the recited objectives, a method is disclosed of sensing cardiogenic oscillations in a patient's airflow and monitoring the patient's cardiac condition from the cardiogenic oscillations. The apparatus diagnoses cardiac morbidity conditions, such as the existence of arrhythmias or other cardiac abnormalities and influences and optimizes cardiac stroke volume. The apparatus further monitors pulse-transit time, changes in the heart pre-ejection period, and the duration of the cardiac cycle.

Brief Description of the Figures

[0015] To further satisfy the recited objectives, a detailed description of typical embodiments of the invention is provided with reference to appended drawings that are not intended to limit the scope of the invention, in which:

[0016] Figure 1 is a diagram of an apparatus that treats sleep disordered breathing during sleep and monitors cardiac signals in a CPAP patient's airflow to assess cardiac health and treat cardiac conditions; and

[0017] Figure 2 is a graph illustrating, over a selected time period, airflow, ECG and mask air pressure.

Description of the Invention

[0018] Turning to Figure 1, a device for treating SDB during sleep is disclosed that is capable of carrying out the features of the invention (such as a CPAP device), including sensing cardiogenic oscillations in air pressure/flow readings to determine whether an apnea event is central or obstructed. Mask flow is measured using a flow sensor 4f and/or pressure sensor 4p with a pneumotachograph and differential pressure transducer or similar device. A flow signal F(t) is derived and mask pressure is measured at a pressure tap using a pressure transducer to derive a pressure signal $P_{mask}(t)$. The pressure sensor 4p and flow sensor 4f have been shown only symbolically in Figure 1 since those skilled in the art would understand how to measure flow and pressure.

[0019] Flow F(t) and pressure $P_{mask}(t)$ signals are sent to a controller or microprocessor 6 which then determines how to adjust the blower. The controller 6 may include integrated circuits, a memory and/or other instruction or data storage medium. Programmed instructions with control methodology may be coded on integrated chips in the memory of the device (e.g., firmware) or loaded as software.

[0020] The pressure delivery device includes a blower 8, which preferably is an impellor. The impellor 8 is controlled by a servo 10, receives ambient air through an inlet 12 and delivers pressurized air through an outlet 14 defined by an air delivery conduit 16 and a mask 18 with an integrated exhaust vent 20. The impellor, motor, and controller assembly define a blower assembly and are located within the blower housing 22. Various switches 24 and displays 26 are provided in the blower housing. A number of sensors are provided within the blower to monitor, among other things, snore 28, motor speed 30, and motor current 32. Various devices known in the art can serve as these

types of sensors. A communication interface 34 allows data to be transferred between the apparatus and an external device, such as a computer or controller.

[0021] If cardiogenic oscillations are not reflected in the pressure in a patient's mask during an apnea event, then the patient may be experiencing an obstructed central apnea event or an obstructed apnea event with respiratory effort. The above measuring technique, by itself, is incapable of differentiating the two conditions so that an indicator of respiratory effort is required. One type of known detector detects when the skin in the suprasternal notch is sucked inwards (during inhalation) and when the skin bulges outward (during expiratory efforts). Such a device is taught in U.S. Patent No. 6,445,942, incorporated herein by reference, which can be used to identify the occurrence of a central apnea.

[0022] Figure 2 illustrates traces that may be recorded by appropriate equipment. Trace 42 illustrates a patient's electrocardiogram (ECG), trace 44 is the CPAP patient's airflow and trace 46 is the patient's air pressure as measured using the CPAP treatment device. (Either or both of airflow and pressure may be monitored.) In the vicinity of numeral 47, the respiratory flow hovers around zero , indicating an apnea event. The air pressure trace 46 still exhibits cardiogenic oscillations 48 indicative of an open airway (unobstructed) central apnea event.

[0023] When monitoring air pressure 46, a band filter may be used. A suitable filter rejects signals of 30 Hz or lower (i.e., rejects those signals which are generally associated with respiration and physical movement of the patient) and also rejects signals higher than 60 Hz (i.e., reject those signals which are generally associated with system noise rather than being representative of cardiogenic events).

[0024] Once cardiogenic information is in hand, it can be used to better manage conventional triggering circuits for a bi-level CPAP ventilator (which typically adjust the ventilator in response to inspiratory and expiratory flow), since distortions of air flow measurements attributable to cardiogenic oscillations can be ignored. Of particular

interest is the identification and filtering out of cardiogenic flow oscillation occurring at the end-expiration (i.e., cardiogenic oscillation signals occurring at a part of the respiratory phase when it is desirable for the ventilator to most accurately cycle from expiration to inspiration in accordance with the applicable treatment algorithm).

[0025] Studying the presence of cardiogenic oscillations and, if present, their amplitude and frequency, during an open apnea event over a period of several seconds, without the complication of the concurrent existence of the airflow signal, provides information concerning the patient's cardiac condition. A medical practitioner can assess the patient's cardiac condition and treatment needs given the known association of central apneas and cardiac morbidity.

[0026] While the cardiogenic airflow may be detected during any portion of the patient's respiratory cycle, the best resolution of the cardiogenic oscillations 48 occurs during the middle to end of the expiration portion 49 of the patient's breath. Monitoring the signal in only this relatively small window simplifies the processing needed to achieve the requisite signal resolution. Indeed, for some applications, it may be sufficient to monitor cardiogenic oscillations during only that portion of the respiratory cycle, i.e., significantly less than all the heartbeats per breath.

[0027] To locate the middle to end of the expiratory cycle, the controller detects the start of a new expiration cycle (with a threshold detector that detects the zero line transition), and identifies the end of the exhalation based on the recent averaged lapsed time of breathing cycles. Alternatively, the later portion of exhalation may be isolated using continuous phase monitoring of the patient's breathing, as disclosed in the '957 patent referenced above.

[0028] Through long term monitoring of the cardiogenic oscillations 48, irregularities in the force or rhythm of the heartbeat signal can be detected, which enables the determination of an arrhythmia. The amplitude and/or frequency of the signal may be compared to thresholds representing expected or prior average heartbeat force and/or

rhythm for the patient to determine any deviation from a norm. Similarly, other patterns indicative of arrhythmia or normal cardiac force/rhythm may be stored as templates and compared to the signal to detect the presence of an arrhythmia or the absence of normal cardiac functioning.

[0029] If an arrhythmia is detected, then the device may send a signal to the patient, care provider or physician, or record the event for later observation. The signal to the patient may be in the form of an audible alarm. The signal to the care provider or physician may be in the form of an automated text messaging system using known telephonic circuitry and a subscription to a cellular provider. Immediate action and treatment is therefore enabled which is particularly useful in view of the known co-morbidity involving cardiac conditions and respiratory disorders such as SDB.

[0030] The determination of cardiac timing is possible by monitoring the average time between cardiogenic oscillations such as 50 and 52. From this timing, heart rate parameters can be deduced such as average rate, variability and arrhythmia. All information regarding cardiac conditions may be observed in real time by way of suitable display, transmitted or recorded. Ventilatory support may be modified so as to assist cardiac function where, for example, CPAP therapy pressure is changed according to the cardiac cycle to assist right atria filling (pressure decrease), left ventricular ejection (pressure increase), and cardiac perfusion (pressure increase at early diastole), etc.

[0031] It has been observed that cardiac stroke volume affects the amplitude of cardiogenic oscillations and that CPAP treatment affects stroke volume. Therefore, by monitoring cardiogenic oscillations in accordance with the present invention, it is possible to titrate CPAP treatment so as to influence and preferably to optimize cardiac stroke volume. This may be achieved without uninterrupted monitoring of heartbeats. Rather it may be achieved with the monitoring of only 1-2 heartbeats per breath, i.e., by monitoring only during a portion of the respiratory cycle, preferably during the middle to end expiration portion. For example, stroke volume may be maximized by examining the

amplitude of the cardiogenic oscillations and servo-controlling the pressure treatment accordingly.

[0032] It has been proposed that pulse-transit time (PTT) may serve as a non-invasive means of inferring respiratory effort and arousals. The PTT is the time in which a pulse wave propagates the length of an arterial tree and is measured by the time interval that starts when half of the ventricular myocardium has been depolarized and ends when the blood is saturated with a predetermined percentage (depending on the age and condition of the patient) of oxyhemoglobin (SpO_2). The former occurs when an R-wave is sensed in the ECG QRS complex (the entire time it takes for depolarization of the ventricles), and the latter occurs when a typical finger pulse oximeter senses photoplethysmographic (pulse) waveforms.

[0033] The disadvantage of the typical measurements of the PPT is that the pre-ejection period (PEP) is included in the measured delay. The present invention allows for the achievement of a more accurate measure of pulse-transit time (i.e., a measure of pulse-transit time without the pre-ejection period component). By performing uninterrupted monitoring of cardiogenic oscillations concurrently with pulse oximetry, PTT may be estimated. An advantage of the present invention is that it uses cardiogenic oscillations for measuring cardiac timing. The cardiogenic oscillations relate to the heart's mechanical systolic events rather than the electrical systolic events, so the PEP is not included.

[0034] Changes in the heart's PEP can also be assessed by the concurrent monitoring of cardiogenic oscillations against the ECG trace 42, and following the lag in time between electrical and mechanical systolic events. The changes in the PEP reflect the ability of the left ventricle to eject (perform mechanical systole events) and are another indication of cardiac health, and blood pressure, as well as peripheral vascular resistance and other cardio-circulatory conditions of interest in patient management.

[0035] In summary, the apparatus may be configured or programmed to do the following while the patient is wearing a mask: measure airflow; identify and isolate the cardiogenic signal from the airflow; identify central apneas; calculate heart rate from the cardiogenic signal; determine abnormalities in heart rate (e.g., arrhythmias); generate notifications if an abnormality is determined, where the notifications include an alarm or other means of contacting selected individuals; monitor cardiac timing and assist in cardiac function; more accurately determine respiratory effort; and monitor PTT and PEP.

[0036] The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not as restrictive. The scope of the invention is, therefore, indicated by the appended claims and their combination in whole or in part rather than by the foregoing description. All changes that come within the meaning and range of equivalency of the claims are to be embraced within their scope.

Claims

What is claimed is:

1. A method of determining a patient's cardiac condition by using a CPAP apparatus for treating sleep disordered breathing, comprising the steps of:

sensing the patient's cardiogenic pressure or flow oscillations; and

using the sensed cardiogenic oscillations to determine the patient's cardiac condition.

2. The method of claim 1 wherein the occurrence of a central apnea event is identified by determining the occurrence of cardiogenic oscillations during a period of no airflow and wherein the patient's cardiac condition is determined based upon the known association of central apneas and cardiac morbidity.

3. The method of claim 1 wherein cardiogenic oscillations in only the middle to later portion of exhalation are used to determine the patient's cardiac condition.

4. The method of claim 3 wherein the middle to later portion of exhalation is determined by tracking the recent averaged lapsed time of prior breathing cycles and using such time in conjunction with the detection of the start of a breathing cycle.

5. The method of claim 1 further comprising the step of sending a signal to the patient, care provider or physician, or recording an arrhythmia event for later observation, upon determining the existence of an arrhythmia event.

6. The method of claim 1 further comprising the step of determining cardiac timing from the time between cardiogenic oscillations.

7. The method of claim 1 further comprising the step of adjusting the patient's stroke volume by examining the amplitude of the cardiogenic oscillations and in accordance therewith adjusting the CPAP treatment pressure.

8. The method of claim 1 further comprising the step of analyzing the cardiogenic oscillations to determine the patient's pulse transit time.

9. The method of claim 1 further comprising the step of analyzing the cardiogenic oscillations against ECG waveforms to determine changes in the patient's pre-ejection period.

10. The method of claim 1 further comprising the step of assisting cardiac function in accordance with the determined cardiac condition by adjusting the CPAP treatment pressure to assist right atria filling, left ventricular ejection, or cardiac perfusion.

11. The method of claim 1 further comprising the step of assisting cardiac function by adjusting the CPAP treatment pressure to assist right atria filling, left ventricular ejection, or cardiac perfusion. Or arterial (aortic) tone?

12. The method of claim 1 further comprising the step of using cardiogenic oscillation information for managing triggering of a bi-level CPAP apparatus.

13. A method of determining a patient's cardiac condition and providing cardiac treatment by using a CPAP apparatus for treating sleep disordered breathing, comprising the steps of:

sensing the patient's cardiogenic pressure or flow oscillations; and

using the sensed cardiogenic oscillations to determine the patient's cardiac condition and adjust the pressure delivered by the CPAP apparatus to treat the patient's cardiac condition.

14. The method of claim 13 wherein the occurrence of a central apnea event is identified by determining the occurrence of cardiogenic oscillations during a period of no airflow and wherein the patient's cardiac condition is determined based upon the known association of central apneas and cardiac morbidity.

15. The method of claim 13 wherein cardiogenic oscillations in only the middle to later portion of exhalation are used to determine the patient's cardiac condition.

16. The method of claim 15 wherein the middle to later portion of exhalation is determined by tracking the recent averaged lapsed time of prior breathing cycles and using such time in conjunction with the detection of the start of a breathing cycle.

17. The method of claim 13 further comprising the step of sending a signal to the patient, care provider or physician, or recording an arrhythmia event for later observation, upon determining the existence of an arrhythmia event.

18. The method of claim 13 further comprising the step of determining cardiac timing from the time between cardiogenic oscillations.

19. The method of claim 13 further comprising the step of adjusting the patient's stroke volume by examining the amplitude of the cardiogenic oscillations and in accordance therewith adjusting the CPAP treatment pressure.

20. The method of claim 13 further comprising the step of analyzing the cardiogenic oscillations to determine the patient's pulse transit time.

21. The method of claim 13 further comprising the step of analyzing the cardiogenic oscillations against ECG waveforms to determine changes in the patient's pre-ejection period.

22. The method of claim 13 further comprising the step of assisting cardiac function in accordance with the determined cardiac condition by adjusting the CPAP treatment pressure to assist right atria filling, left ventricular ejection, or cardiac perfusion.

23. The method of claim 13 further comprising the step of assisting cardiac function by adjusting the CPAP treatment pressure to assist right atria filling, left ventricular ejection, or cardiac perfusion.

24. The method of claim 13 further comprising the step of using cardiogenic oscillation information for managing triggering of a bi-level CPAP apparatus.

25. A CPAP apparatus which, in addition to providing CPAP therapy, determines a patient's cardiac condition, the apparatus comprising a controller and a sensor for detecting pressure in the patient's CPAP mask, wherein the controller:

senses the patient's cardiogenic pressure oscillations; and

uses the sensed cardiogenic oscillations to determine the patient's cardiac condition.

26. The apparatus of claim 25 wherein the controller:

identifies a central apnea event by determining the occurrence of cardiogenic oscillations during a period of no airflow; and

determines the patient's cardiac condition based upon the known association of central apneas and cardiac morbidity.

27. The apparatus of claim 25 wherein the controller uses cardiogenic oscillations in only the middle to later portion of exhalation to determine the patient's cardiac condition.

28. The apparatus of claim 27 wherein the controller determines the middle to later portion of exhalation by tracking the recent averaged lapsed time of prior breathing cycles and using such time in conjunction with the detection of the start of a breathing cycle.

29. The apparatus of claim 25 wherein the controller sends a signal to the patient, care provider or physician, or recording an arrhythmia event for later observation, upon determining the existence of an arrhythmia event.

30. The apparatus of claim 25 wherein the controller determines cardiac timing from the time between cardiogenic oscillations.

31. The apparatus of claim 25 wherein the controller adjusts the patient's stroke volume by examining the amplitude of the cardiogenic oscillations and in accordance therewith adjusting the CPAP treatment pressure.

32. The apparatus of claim 25 wherein the controller analyzes the cardiogenic oscillations to determine the patient's pulse transit time.

33. The apparatus of claim 25 wherein the controller analyzes the cardiogenic oscillations against ECG waveforms to determine changes in the patient's pre-ejection period.

34. The apparatus of claim 25 wherein the controller assists cardiac function in accordance with the determined cardiac condition by adjusting the CPAP treatment pressure to assist right atria filling, left ventricular ejection, or cardiac perfusion.

35. The apparatus of claim 25 wherein the controller assists cardiac function by adjusting the CPAP treatment pressure to assist right atria filling, left ventricular ejection, or cardiac perfusion.

36. The apparatus of claim 25 wherein the controller uses cardiogenic oscillation information for managing triggering of the CPAP apparatus.

37. A CPAP apparatus which, in addition to providing CPAP therapy, determines a patient's cardiac condition and provides cardiac treatment, the apparatus comprising a controller and a sensor for detecting pressure in the patient's CPAP mask, wherein the controller:

senses the patient's cardiogenic pressure oscillations; and

uses the sensed cardiogenic oscillations to determine the patient's cardiac condition.

38. The apparatus of claim 37 wherein the controller:

identifies the occurrence of a central apnea event by determining the occurrence of cardiogenic oscillations during a period of no airflow; and

determines the patient's cardiac condition based upon the known association of central apneas and cardiac morbidity.

39. The apparatus of claim 37 wherein the controller uses cardiogenic oscillations in only the middle to later portion of exhalation are used to determine the patient's cardiac condition.

40. The apparatus of claim 39 wherein the controller determines the middle to later portion of exhalation by tracking the recent averaged lapsed time of prior breathing cycles and using such time in conjunction with the detection of the start of a breathing cycle.

41. The apparatus of claim 37 wherein the controller sends a signal to the patient, care provider or physician, or recording an arrhythmia event for later observation, upon determining the existence of an arrhythmia event.

42. The apparatus of claim 37 wherein the controller determines cardiac timing from the time between cardiogenic oscillations.

43. The apparatus of claim 37 wherein the controller adjusts the patient's stroke volume by examining the amplitude of the cardiogenic oscillations and in accordance therewith adjusting the CPAP treatment pressure.

44. The apparatus of claim 37 wherein the controller analyzes the cardiogenic oscillations to determine the patient's pulse transit time.

45. The apparatus of claim 37 wherein the controller analyzes the cardiogenic oscillations against ECG waveforms to determine changes in the patient's pre-ejection period.

46. The apparatus of claim 37 wherein the controller assists cardiac function in accordance with the determined cardiac condition by adjusting the CPAP treatment pressure to assist right atria filling, left ventricular ejection, or cardiac perfusion.

47. The apparatus of claim 37 wherein the controller assists cardiac function by adjusting the CPAP treatment pressure to assist right atria filling, left ventricular ejection, or cardiac perfusion.

48. The apparatus of claim 37 wherein the controller uses cardiogenic oscillation information for managing triggering of a bi-level CPAP apparatus.

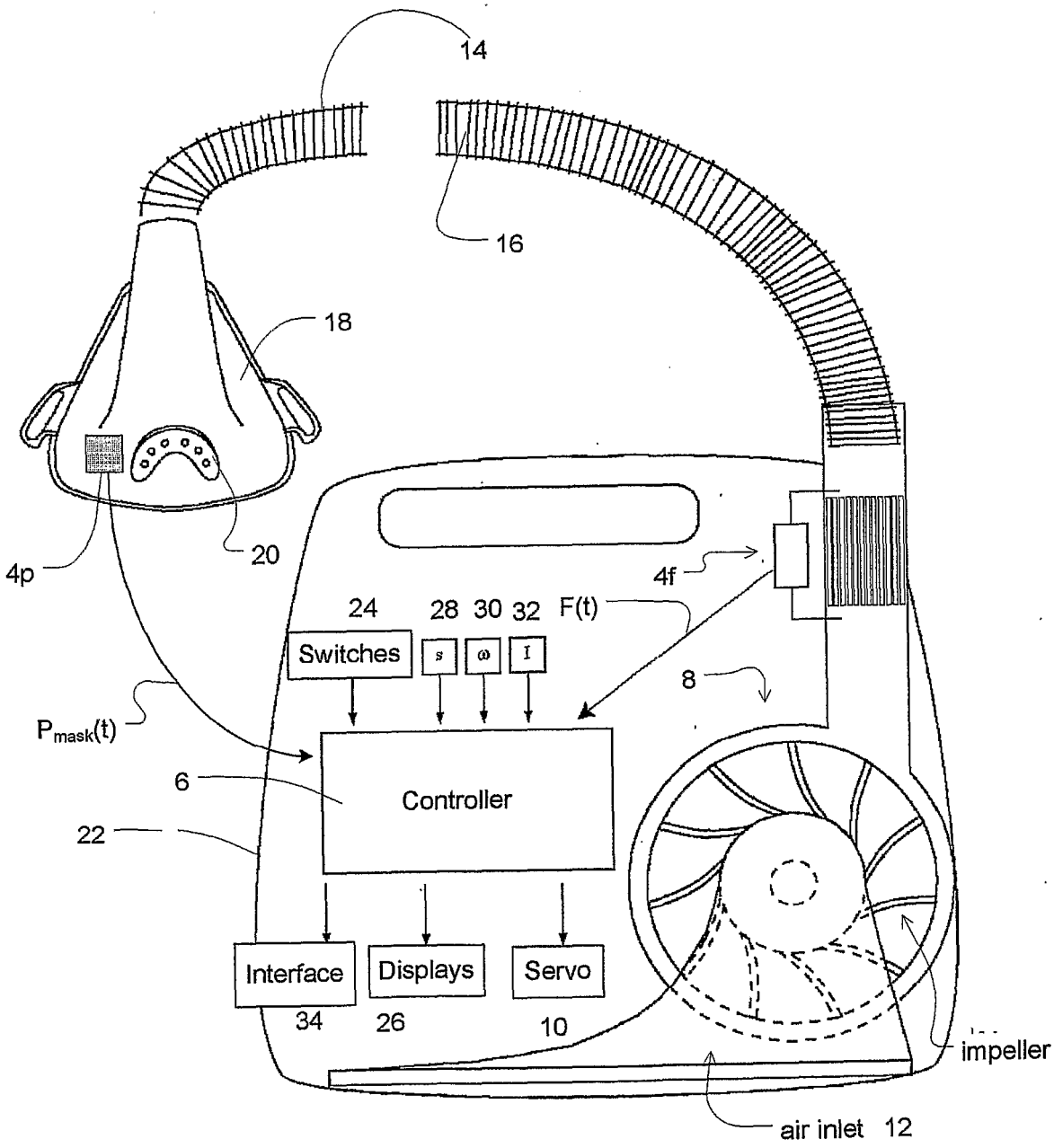

14
16
18
20
4p
4f
24
28
30
32
F(t)
Switches
s
ω
I
8
$P_{mask}(t)$
6
Controller
22
Interface
Displays
Servo
34
26
10
impeller
air inlet 12

FIG. 1

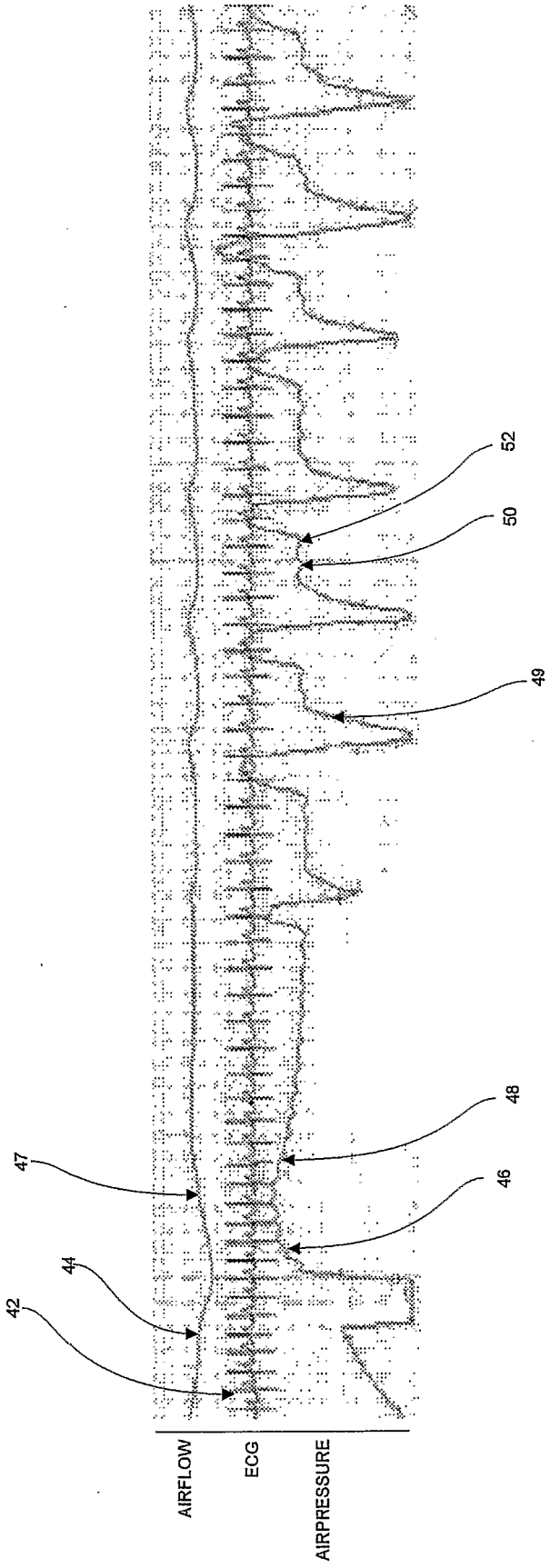


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2005/000248

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: A61M 16/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI +keywords: CPAP, cardiac, oscillate and similar terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,029,665 A (BERTHON-JONES) 29 February 2000 Column 4 lines 29 to 31	1-6, 8, 12, 25-30, 32, 36-42, 44
Y	Chest, 1999 September, 116(3):660-666 "Cardiogenic oscillations on the airflow signal during continuous positive airway pressure as a marker of central apnea" Ayappa et al Whole document	1-6, 8, 12, 25-30, 32, 36-42, 44
Y	Anesth Analg, 1978 November-December, 57(6):647-652 "Automated measurement and frequency analysis of the Pneumocardiogram" Reitan et al Whole document	1-6, 8, 12, 25-30, 32, 36-42, 44

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 March 2005	22 MAR 2005
Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	**XAVIER GISZ** Telephone No : (02) 6283 2064

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2005/000248

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	IEEE Trans Biomed Eng, 1981 June, 28(6):471-5 "The dynamic pneumocardiogram: an application of coherent signal processing to cardiovascular measurement" Johnson Whole document	
A	US 5,794,615 A (ESTES) 18 August 1998 Abstract	
A	WO 2002/026283 A2 (RESPIRONICS, INC) 4 April 2002 Abstract	
A	US 6,532,959 B1 (BERTHON-JONES) 18 March 2003 Abstract	
A, P	US 6,739,335 B1 (RAPPORT et al) 25 May 2004 Abstract	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU2005/000248

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	6029665	AU	36787/99	AU	55382/98	AU	55383/98
		AU	77641/94	EP	0651971	EP	0920845
		EP	0927538	EP	0934723	EP	1488743
		US	5704345	US	6138675	US	6363933
		US	6675797	US	2004123866		
US	5794615	AU	30801/99	CA	2323455	EP	1061981
		US	5535738	US	6105575	US	6609517
		US	2003121519	WO	9945989	WO	2004047621
WO	0226283	AU	93060/01	BR	0114152	CA	2421774
		EP	1328305	US	6752151	US	2002088465
		US	2004221848				
US	6532959	AU	31211/99	AU	37099/01	AU	40236/99
		EP	1083953	US	2003154979	US	2004237963
		WO	9961088				
US	6739335						

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX

专利名称(译)	使用用于提供睡眠呼吸障碍的压力治疗的装置的心脏监测和治疗		
公开(公告)号	EP1718356A1	公开(公告)日	2006-11-08
申请号	EP2005706284	申请日	2005-02-24
[标]申请(专利权)人(译)	雷斯梅德有限公司		
申请(专利权)人(译)	瑞思迈有限公司		
当前申请(专利权)人(译)	瑞思迈有限公司		
[标]发明人	PHUAH CHEE KEONG RESMED LIMITED FARRUGIA STEVEN PAUL RESMED LIMITED CHAN CHRISTINE WEI CHIH		
发明人	PHUAH, CHEE KEONG, RESMED LIMITED FARRUGIA, STEVEN PAUL, RESMED LIMITED MARTIN, DION CHARLES CHEWE, RESMED LIMITED CHAN, CHRISTINE, WEI, CHIH		
IPC分类号	A61M16/00 A61B5/00 A61B5/0205 A61B5/024 A61B5/0464 A61B5/087 A61M16/06 A61M16/08		
代理机构(译)	阿斯奎斯，朱利安PETER		
优先权	60/547812 2004-02-25 US		
其他公开文献	EP1718356B1 EP1718356A4		
外部链接	Espacenet		

摘要(译)

一种使用CPAP设备感测患者气流中的心源性振荡，以及监测和治疗患者心脏状况的方法。该装置诊断心脏病发病状况，例如心律失常或其他心脏异常的存在，并影响和优化心脏搏出量。该装置还监测脉冲传播时间，心脏射血前期的变化和心动周期的持续时间。