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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 November 2005 (03.11.2005)

PCT

(10) International Publication Number
WO 2005/102163 A1

(51) International Patent Classification[7]: A61B 5/083, 5/00

(21) International Application Number: PCT/NO2005/000131

(22) International Filing Date: 20 April 2005 (20.04.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2004 1611 20 April 2004 (20.04.2004) NO

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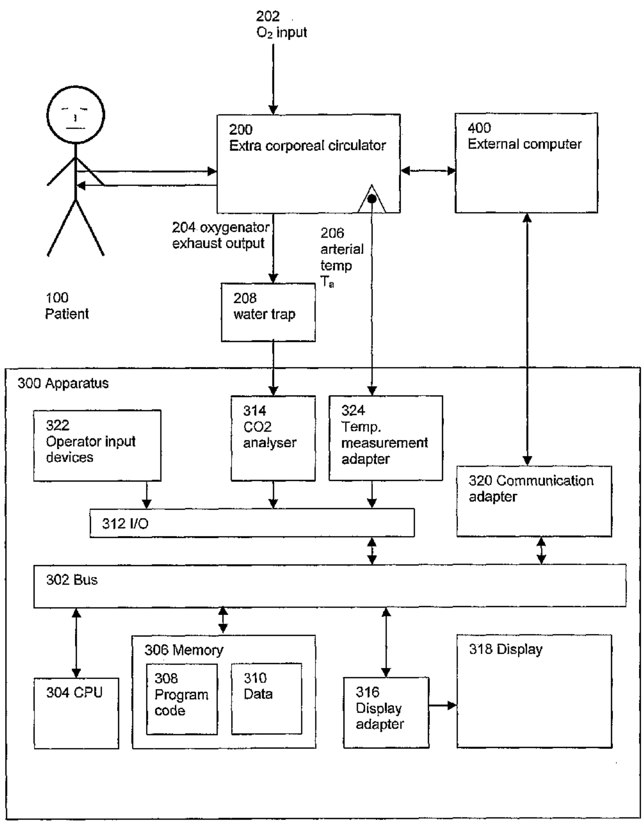
(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, 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, SM, 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,

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR ESTIMATING A PACO2 VALUE FOR A PATIENT SUBJECT TO EXTRA CORPOREAL CIRCULATION



(57) Abstract: The invention relates to a method and an apparatus for estimating a P_aCO_2 value for a patient subject to extracorporeal circulation by means of an oxygenator. The method comprises the steps of measuring a $P_{ex}CO_2$ value in the exhaust gas of the oxygenator and the patient's arterial blood temperature value T_a, using a temperature sensor arranged in the oxygenator. The estimated P_aCO_2 value is then calculated, based on the measured $P_{ex}CO_2$ value and the arterial temperature measurement. Advantageously, an average value determined from a predetermined number of recent $P_{ex}CO_2$ values is used in the calculation. The calculation is performed by adding a correction term to the $P_{ex}CO_2$ value, which is composed of a temperature dependent component and an offset component. The correction term may be adjusted by a user. The estimated P_aCO_2 value is presented on a display. A switch provides easy alteration between pH-stat mode and alpha-stat mode.

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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*

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METHOD AND APPARATUS FOR ESTIMATING A P_aCO_2 VALUE FOR A PATIENT SUBJECT TO EXTRACORPOREAL CIRCULATION

Technical field

The present invention relates in general to the field of medical technology.

More specifically, the invention relates to a method and an apparatus for estimating a P_aCO_2 value representing the arterial partial pressure of CO_2 for a patient subject to extracorporeal circulation by means of an oxygenator.

Background of the invention

During cardiopulmonary bypass (CPB) there is a need for reliable, accurate and instant estimates of the arterial blood CO_2 tension (P_aCO_2) of the patient.

Currently, the regular practice for measuring P_aCO_2 during cardiopulmonary bypass involves the manual collection of intermittent blood samples, followed by a separate analysis performed by a gas analyser. This approach involves a substantial delay in the acquiring of data, as well as undesirable manual steps.

Probes for inline blood gas measurements exist, but they are expensive and thus not applicable for routine use.

A well known approach is to measure $P_{ex}CO_2$, i.e. the partial pressure of CO_2 in the exhaust gas output from the oxygenator used in the extracorporeal circulation equipment, and use this measurement as a direct estimate for P_aCO_2.

Changes in temperature inevitably affect the acid-base balance, and management of both pH and CO_2 is of special concern during deep hypothermia. Two commonly used management protocols or blood gas strategies are known as the pH-stat strategy and the alpha-stat strategy. According to the pH-stat strategy, pH is held constant, while temperature and PCO_2 are allowed to change. In alpha-stat strategy, PCO_2 is held constant while the temperature and pH are allowed to change.

When operating according to the pH-stat strategy the direct estimate approach, i.e. using $P_{ex}CO_2$ directly as an estimate for P_aCO_2, is appropriate.

However, when operating according to the alpha-stat strategy, the direct estimate approach leads to seriously inaccurate results, in particular at deep hypothermia.

Several studies have been previously accomplished, relating to the problem of estimating P_aCO_2 values for a patient subject to extracorporeal circulation.

For instance, Potger et al, in the article *Membrane Oxygenator Exhaust Capnography for continuously estimating arterial carbone dioxide tension during* *cardiopulmonary bypass* (J. of the American Society of Extra-Corporeal Technology, 2003:35:218-223), reports that a correlation has been found between the $P_{ex}CO_2$ and a temperature corrected P_aCO_2.

Likewise, M. J. O'Leary et. al: *Oxygenator exhaust capnography as an index of arterial carbon dioxide tension during cardiopulmonary bypass using a membrane oxygenator*, (Br. J. of Anaesth 1999 82:(6): 843-6), and the subsequent comments by W.M. Weightman et. al, (Br. J. Anaesth. 2000 84: 536-537) discuss various relations between P_aCO_2, $P_{ex}CO_2$ and the body temperature of the patient.

However, none of these publications actually disclose a practical, reliable, accurate and cost-effective method and apparatus for estimating P_aCO_2 values for a patient subject to extracorporeal circulation.

Summary of the invention

An object of the present invention is to provide a method and an apparatus for estimating a value (P_aCO_2) representing the arterial partial pressure of CO_2 for a patient subject to extracorporeal circulation by means of an oxygenator, which overcome the disadvantages of the prior art.

A particular object of the present invention is to provide such a method and an apparatus which provide accurate results, which is reliable, easy to operate, and which is inexpensive with regard to manufacturing and use.

A further object of the invention is to provide such a method and an apparatus which may be calibrated before use, and which also may be adjusted by the user during operation.

An additional object of the invention is to provide such a method and an apparatus which utilizes already present devices in the existing extracorporeal circulation equipment, avoiding further components to come in contact with the circulating blood of the patient.

Still another object of the invention is to provide such a method and an apparatus which may be operated according to pH-stat strategy or alpha-stat strategy, whereby the alternation between the two operation modes may be changed easily by the user.

The above objects and further advantages are achieved by a method and an apparatus as set forth in the appended set of claims.

Additional features and principles of the present invention will be recognized from the detailed description below.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and not restrictive of the invention, as claimed.

Brief description of the drawings

The accompanying drawings illustrate a preferred embodiment of the invention. In the drawings,

Fig. 1 is a schematic block diagram illustrating an apparatus according to the invention included in its operating environment, and

Fig. 2 is a schematic flow chart illustrating a method according to the invention.

Detailed description of the invention

Reference will now be made in detail to the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

Fig. 1 is a schematic block diagram illustrating an apparatus according to the invention included in its operating environment.

The illustrated apparatus 300 is an apparatus for estimating a P_aCO_2 value, representing the arterial partial pressure of CO_2 for a patient 100 subject to extracorporeal circulation by means of an oxygenator incorporated in the extracorporeal circulator 200.

The apparatus 300 comprises a measuring device 314, in particular a CO_2 analyzer, for measuring a $P_{ex}CO_2$-value representing the partial pressure of CO_2 in the substantially continuous and laminar flow of exhaust gas which is supplied by the oxygenator exhaust output 204.

The gas inlet of the CO_2 analyzer 314 is equipped with a connector adapted for the releasable connection of a disposable tube, which is equipped with a disposable water trap 208, conveying exhaust gas from the oxygenator exhaust output 204.

The CO_2 analyzer 314 comprises a CO_2 sensor, which may be, e.g., based on measurements of the absorption of infrared radiation through a sample cell which contains the gas to be analyzed. The CO_2 analyzer also comprises electronic circuitry for signal processing. An example of a CO_2 analyzer applicable for use with the present invention is the Square One 2125 gas analyzer. A disclosure of an appropriate CO_2 analyzer is also presented in US-5 932 877, which is hereby incorporated by reference.

The apparatus is designed as a processor-based instrument with a regular processor bus structure. As illustrated, a bus 302 is connected to a processing device 304, in particular a microprocessor. The bus 302 is further connected to a memory 306, comprising a program code portion 308, preferably contained in a non-volatile part of the memory 306 such as an EEPROM or a Flash memory, and a data portion 310, preferably contained in a volatile part of the memory 306 such as a RAM. Advantageously, non-executable data, such as parameters that should be maintained even if the power supply of the apparatus is switched off, may also be held in the non-volatile part of the memory 306.

The processing device 304 is arranged to execute the program code held in the program code portion 308 in the memory 306. In particular, the program code comprises instructions which cause the processor device 304 to perform the steps of the method according to the invention or to perform actions which in turn causes the apparatus 300 to perform the steps of the method according to the invention, as described below in particular with reference to fig. 2. The coding of an appropriate program code implies an ordinary task for a person skilled in the art, based on the disclosure set forth in the present specification.

The processor device 304 is thus arranged to, when executing the program code 308, to calculate the estimated P_aCO_2 value, dependent on the $P_{ex}CO_2$ value measured in said exhaust gas, and a the temperature value T_a of the patient's arterial blood temperature.

The apparatus advantageously comprises a low pass filter, arranged for low pass filtering said $P_{ex}CO_2$ value provided by the CO_2 analyzer 314. The aim of such a filter is to reduce the effects of rapid fluctuations in the measured $P_{ex}CO_2$ value. This filter may be implemented in several ways. For instance, it may be implemented as an analog LP filter, reducing the most rapid changes in an analog signal corresponding to the $P_{ex}CO_2$ value.

More advantageously, the LP filter is implemented digitally, as the processing device 304 is arranged to calculate an average value of a number of recently measured $P_{ex}CO_2$ values. This may again be implemented by putting each incoming $P_{ex}CO_2$ value in a FIFO queue structure with a predetermined number N of elements, and by arranging the processing device to read all elements in the FIFO data structure, and to calculate a running average value for the recent N $P_{ex}CO_2$ values. The number N may be selected by the skilled person, based on, inter alia, the sampling rate of the $P_{ex}CO_2$ readings. In an example embodiment, N=20.

The processing device 304 is further arranged to perform the calculating of the estimated P_aCO_2 value by adding a correction value to the $P_{ex}CO_2$ value of partial pressure in the exhaust gas.

The correction value is advantageously substantially linearly dependent on said temperature value T_a. In particular, the correction value is calculated as a proportionality constant (a), multiplied by the temperature value T_a 206, added to an offset constant (b).

The proportionality constant (a) and the offset constant (b) are advantageously generated in advance, by means of a preceding calibration procedure. The constants are then stored in a part of the memory 306, preferably in a non-volatile part of the memory 306.

The apparatus 300 further comprises input devices 322 for operation by a user of the apparatus. In particular, the apparatus 300 comprises an input device which is arranged for setting or adjusting the proportionality constant (a) and the offset constant (b). This input device may be embodied as analog operating devices such as rotating buttons, or by pushbuttons such as the keys of a keyboard, whereby the user may, e.g., enter numerical values.

The input devices 322, the CO_2 analyzer 314 and a temperature measurement adapter 324 are all connected to an I/O device 312, which in turn is connected to the internal bus 302 of the apparatus 300.

The arterial temperature Ta is measured by means of a temperature sensor 206, in particular a thermocouple, which is inserted in the oxygenator in the extracorporeal circulator 200, and thereby arranged to measure the arterial blood temperature.

The temperature sensor 206 is connected to the input of the temperature measurement adapter 324, which is arranged to convert the sensor signal to a digital signal, adapted to be read by the system bus 312.

The apparatus 300 advantageously comprises a display adapter 316, connected to the bus 302 and further to a display 318. The display 318 may e.g. be an LCD display.

The processing device 304 is further arranged to display the estimated P_aCO_2 value on the display 318.

The input devices 322 advantageously further comprise a mode switch (not illustrated). The operation of the mode switch provides easy alteration between pH-stat mode and alpha-stat mode. The processing device is arranged to, when the mode switch is in pH-stat position, to present the uncorrected $P_{ex}CO_2$ value on the display. The processing device is further arranged to, when the mode switch is in the alpha-stat position, to present the estimated (corrected) P_aCO_2 value on the display.

Alternatively, the processing device may be arranged to set both constants a, b equal to zero when the mode switch is determined to be in pH-stat position.

The input devices 322 may further comprise a start button (not illustrated). The operation of the start button initiates the estimating process according to the invention.

The processing device is advantageously arranged to reiterate the steps of calculating estimated P_aCO_2 values, each time using updated measurement values. This results in a quasi-continuous process, repeatedly providing estimated P_aCO_2 values.

The input devices 322 also advantageously comprise a stop button (not illustrated). The processing device is arranged to terminate the reiteration of the estimating process upon the operation of the stop button.

A communication adapter 320 is connected to the bus 302, enabling communication between the apparatus 300 and an operatively connected, external computer 400. The computer 400 may advantageously also be operatively connected to the extracorporeal circulating equipment 200.

Although not illustrated, the apparatus also comprises a power supply, a casing, connectors for gas and electric signals, operating elements et cetera. The selection and arrangement of such regular components, as well as the constructional details leading to a complete, working apparatus, may readily be performed by a person skilled in the art, without inventive efforts. The skilled person will further realize that the practical implementation of the apparatus should aim at complying with the IEC 60601-1 standard, published by the International Electrotechnical Commission (IEC).

Fig. 2 is a schematic flow chart illustrating a method according to the invention.

The method illustrated in fig. 2 is preferably performed as a microprocessor-implemented process, advantageously by the processor device 304 illustrated in fig. 1.

The illustrated method is a method for estimating a P_aCO_2 value representing the arterial partial pressure of CO_2 for a patient subject to extracorporeal circulation by means of an oxygenator in an extracorporeal circulator.

The method starts at the initiating step 502, e.g. initiated by the operation of a start button included in the operator input devices 322 illustrated in fig. 1.

Next, in step 504, an arterial blood temperature measurement T_a is provided. Advantageously, this value is acquired by use of a temperature sensor usually incorporated in the extracorporeal circulating equipment 200.

Next, in step 506, a measurement $P_{ex}CO_2$ of the partial pressure of CO_2 in the exhaust gas output 204 from the oxygenator is provided.

It will be apparent to the skilled person that the measurement steps 504 and 506 may be performed in the opposite order, or even simultaneously or concurrently, if so desired.

Advantageously, the $P_{ex}CO_2$ value is low pass filtered. This is accomplished by the filtering steps 508 and 510. In step 508, the presently acquired $P_{ex}CO_2$ value is put in a FIFO queue data structure of e.g. N=20 elements. Then, in step 510, the average or mean value of all the FIFO elements are calculated. This leads to a LP filtered $P_{ex}CO_2$ value identical to the mean value of the last N=20 acquired instant values. This filtering reduces the effects of rapid fluctuations in the instant $P_{ex}CO_2$ values.

Of course, the filtering may be omitted or replaced by an alternative filtering process. As an example, another calculating result than the plain arithmetic mean value may be derived from the FIFO values. The resulting output may rather be a weighted average, wherein the most recent instant $P_{ex}CO_2$ values are weighted more dominantly than the less recent instant values. Other possibilities exist within the apprehension of the skilled person.

In step 512 a proportionality constant (a) and an offset constant (b) are provided, preferably fetched from a memory 306. The constants may be pre-generated by a preceding calibration procedure and then stored in the memory. The constants may further advantageously be set or adjusted by an input device included in the operator input devices 322, as explained previously with reference to fig. 1.

The calibration procedure for pre-generating the constants a and b may be performed by the following method:

For a number of different arterial blood temperatures T_a (e.g., 32 °C, 35 °C and 38 °C), and preferably also for a number of different patients (e.g., 10 patients), the $P_{ex}CO_2$ values measured by the CO_2 analyzer is measured and recorded. For each arterial blood temperature value T_a the corresponding "true" P_aCO_2 value is also recorded, provided by manual collection of a blood sample followed by a separate analysis performed by a reference bloodgas analyzer. This leads to a multiple data set of corresponding values for temperatures, $P_{ex}CO_2$ and P_aCO_2. The values for the constants a and b are then easily calculated by regular linear regression, thus establishing the set of constant values (a, b) that most properly fits the equation $P_aCO_2 = P_{ex}CO_2 + aT_a + b$.

Calibration values of the constants a and b may be recorded and supplied for downloading into a memory as constant values associated with a specific oxygenator.

Subsequent to step 512 of providing pre-generated constants a and b, the main calculating step 514 is performed.

In this step, the estimated P_aCO_2 value is established by the formula

$$P_aCO_2 = P_{ex}CO_2 + aT_a + b,$$

wherein $P_{ex}CO_2$ is the preferably averaged or filtered $P_{ex}CO_2$ measurement value, T_a is the measured arterial blood temperature and a, b are constants as explained above.

That is, the estimated P_aCO_2 is calculated as the $P_{ex}CO_2$ value, corrected by adding to it a correction term ($aT_a + b$).

As can be seen of the formula, the correction value is preferably linearly dependent on the arterial blood temperature value (T_a).

However, the skilled person will realize that other models for providing a correction value exist, including correction values provided as 2^{nd}, 3^{rd} or even higher order polynomials of the arterial temperature value. In such cases, a corresponding number of constants are evidently necessary. Tests have however shown that a linear approximation is appropriate for practical purposes.

Next, in step 516, the estimated P_aCO_2 is presented on a display.

If the process is to be terminated, e.g. activated by a pressed stop-button included in the operator input devices 322, the terminating step 520 is performed. Else, the process is reiterated by returning to step 504.

Several modifications and adaptations of the present invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein.

For instance, although the apparatus is illustrated as a complete instrument wherein the processing device, the display and operating devices are all included, the skilled person will readily realize that alternative embodiments also exist within the scope of the invention as defined in the claims. The apparatus may thus be, e.g., embodied as a virtual instrument operating on a general purpose computer such as a PC, executing virtual instrument software such as e.g. LabView, which is further configured in order to operate according to the present invention. LabView is a computer software product for a data acquisition and virtual instrumentation, manufactured by National Instruments Corp., which is well-known to a person skilled in the art. In this case, the computer will either include or operatively be connected to peripheral devices necessary to practice the invention, in particular the CO_2 analyzer and an input port for the arterial temperature signal T_a. However, functions such as the operating devices or switches may effortlessly be implemented as software modules, operating in conjunction with regular computer input devices such as a keyboard and a mouse. The display 318 may correspondingly be substituted by a regular computer display.

The above detailed description of the invention has been presented for purpose of illustration. It is not exhaustive and does not limit the invention to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from the practicing of the invention.

CLAIMS

1. Method for estimating a value (P_aCO_2) representing the arterial partial pressure of CO_2 for a patient subject to extracorporeal circulation by means of an oxygenator, comprising the steps of:

- measuring a value ($P_{ex}CO_2$) representing the partial pressure of CO_2 in the exhaust gas of the oxygenator,
- measuring a temperature value (Ta) representing the patient's arterial blood temperature, and
- calculating the estimated value (P_aCO_2) representing the arterial partial pressure of CO_2, dependent on said value ($P_{ex}CO_2$) representing said partial pressure of CO_2 in said exhaust gas and said temperature value (T_a).

2. Method according to claim 1, wherein said value ($P_{ex}CO_2$) representing the partial pressure of CO_2 in said exhaust gas is low pass filtered, reducing the effects of rapid fluctuations in the measured value.

3. Method according to claim 1 or 2, wherein said value ($P_{ex}CO_2$) is calculated as an average value of a number of recently measured values ($P_{ex}CO_2$) of partial pressure in said exhaust gas.

4. Method according to one of the claims 1-3, wherein said step of calculating said estimated value (P_aCO_2) comprises adding a correction value to the value ($P_{ex}CO_2$) of partial pressure in said exhaust gas, said correction value being substantially linearly dependent on said temperature value (T_a).

5. Method according to claim 4, wherein said correction value is calculated as a proportionality constant (a) multiplied by the temperature value (T_a) added to an offset constant (b).

6. Method according to claim 5, wherein said proportionality constant (a) and said offset constant (b) are pre-generated by a calibration procedure and stored in a memory.

7. Method according to claim 5 or 6, wherein said proportionality constant (a) and said offset constant (b) may be set or adjusted by an input device.

8. Method according to one of the claims 1-7, wherein said step of measuring the temperature value (T_a) is performed by means of

a temperature sensor arranged in an extracorporeal circuit which comprises said oxygenator.

9. Method according to one of the claims 1-8, wherein said step of measuring the value ($P_{ex}CO_2$) representing the partial pressure of CO_2 in the exhaust gas of the oxygenator comprises exposing a substantially continuous and laminar flow provided by the oxygenator exhaust output to the input of a CO_2 sensor.

10. Method according to one of the claims 1-9, further comprising the step of displaying the estimated value (P_aCO_2) presenting the arterial partial pressure of CO_2 on a display.

11. Method according to one of the claims 1-10, reiterated as a pseudo-continuous process until the receipt of a stop signal.

12. Apparatus for estimating a value (P_aCO_2) representing the arterial partial pressure of CO_2 for a patient subject to extracorporeal circulation by means of an oxygenator, comprising
a measuring device for measuring a value ($P_{ex}CO_2$) representing the partial pressure of CO_2 in the exhaust gas of the oxygenator,
a temperature measuring device for providing a temperature value (T_a) representing the patient's arterial blood temperature, and
a processing device, arranged to perform the step of
- calculating the estimated value (P_aCO_2) representing the arterial partial pressure of CO_2, dependent on said value ($P_{ex}CO_2$) representing said partial pressure of CO_2 in said exhaust gas and said temperature value (T_a) representing the patient's arterial blood temperature.

13. Apparatus according to claim 12, further comprising a low pass filter, low pass filtering said value ($P_{ex}CO_2$) representing the partial pressure of CO_2 in said exhaust gas, reducing the effects of rapid fluctuations in the measured value.

14. Apparatus according to claim 12 or 13, wherein said processing device is arranged to calculate the value ($P_{ex}CO_2$) as an average value of a number of recently measured values ($P_{ex}CO_2$) of partial pressure in said exhaust gas.

15. Apparatus according to one of the claims 12-14, wherein said processing device is arranged to perform said step of calculating said estimated value (P_aCO_2) by adding a correction value to the value ($P_{ex}CO_2$) of partial pressure in said exhaust gas, said correction value being substantially linearly dependent on said temperature value (T_a).

16. Apparatus according to claim 15, wherein said processing device is arranged to calculate said correction value as a proportionality constant (a) multiplied by the temperature value (T_a) added to an offset constant (b).

17. Apparatus according to claim 16, wherein said proportionality constant (a) and said offset constant (b) are pre-generated by a calibration procedure and stored in a memory.

18 Apparatus according to claim 16 or 17, further comprising an input device, wherein said processing device is arranged for setting or adjusting said proportionality constant (a) and said offset constant (b) by means of the input device.

19. Apparatus according to one of the claims 12-18, wherein said temperature value (T_a) is measured by means of a temperature sensor arranged in an extracorporeal circuit which comprises said oxygenator.

20. Apparatus according to one of the claims 12-19, wherein said measuring device for measuring the value ($P_{ex}CO_2$) representing the partial pressure of CO_2in the exhaust gas of the oxygenator comprises a CO_2 sensor arranged in conduit supplied by a substantially continuous and laminar flow provided by the oxygenator exhaust output.

21. Apparatus according to one of the claims 12-20, further comprising a display, wherein said processing unit is further arranged to display the estimated value (P_aCO_2) presenting the arterial partial pressure of CO_2 on said display.

22. Apparatus according to one of the claims 12-21, further comprising a stop signal operating device, wherein said processing device is arranged to reiterate said calculating step, using updated measurement values, until the receipt of a stop signal from the stop signal operating device.

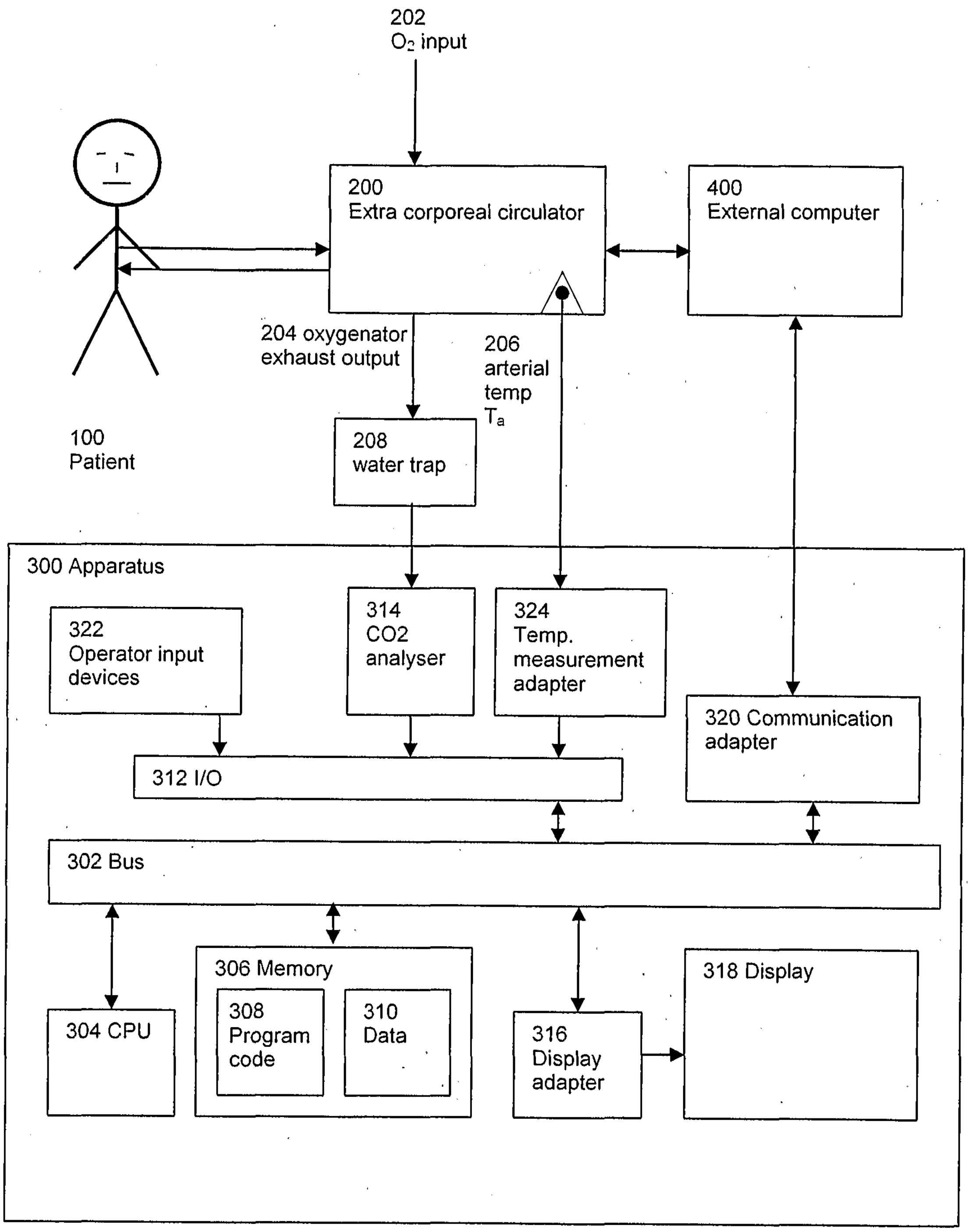
202
O_2 input
200
Extra corporeal circulator
400
External computer
204 oxygenator exhaust output
206
arterial
temp
T_a
100
Patient
208
water trap
300 Apparatus
322
Operator input devices
314
CO2
analyser
324
Temp.
measurement
adapter
320 Communication adapter
312 I/O
302 Bus
306 Memory
304 CPU
308
Program
code
310
Data
316
Display
adapter
318 Display

Fig. 1

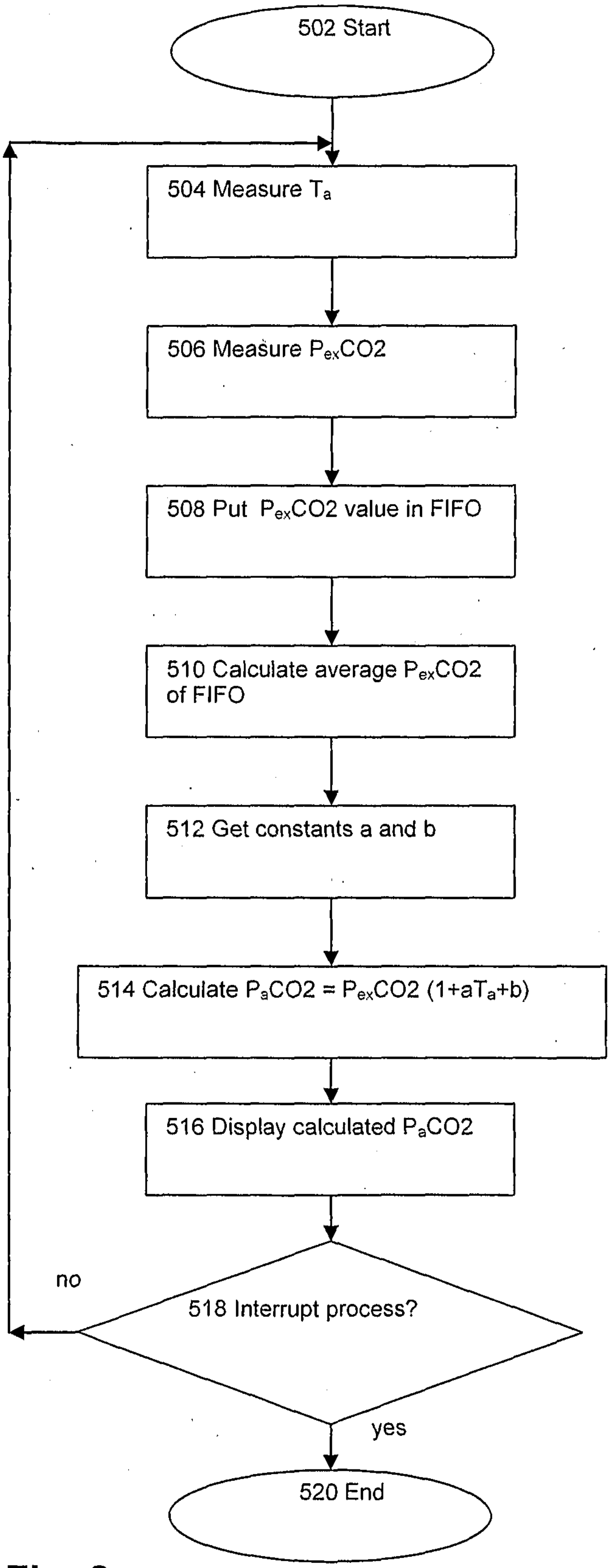
502 Start
504 Measure T_a
506 Measure $P_{ex}CO2$
508 Put $P_{ex}CO2$ value in FIFO
510 Calculate average $P_{ex}CO2$ of FIFO
512 Get constants a and b
514 Calculate $P_aCO2 = P_{ex}CO2\ (1+aT_a+b)$
516 Display calculated P_aCO2
518 Interrupt process?
no
yes
520 End

Fig. 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NO2005/000131

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B5/083 A61B5/00

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)
IPC 7 A61B

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE MEDLINE 'Online! US NATIONAL LIBRARY OF MEDICINE (NLM), BETHESDA, MD, US; September 2003 (2003-09), POTGER KIERON C ET AL: "Membrane oxygenator exhaust capnography for continuously estimating arterial carbon dioxide tension during cardiopulmonary bypass." XP009051090 Database accession no. NLM14653424 cited in the application	12,19
Y	the whole document	13,15, 18,20-22
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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

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"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
1 August 2005	08/08/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Rivera Pons, C

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NO2005/000131

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	& THE JOURNAL OF EXTRA-CORPOREAL TECHNOLOGY. SEP 2003, vol. 35, no. 3, September 2003 (2003-09), pages 218-223, ISSN: 0022-1058	
Y	US 4 269 194 A (RAYBURN ET AL) 26 May 1981 (1981-05-26) column 2, lines 15-58 column 3, line 23 - column 4, line 4 column 5, lines 10-23 column 8, line 41 - column 9, line 54	13,15, 18,20-22
A	claim 1	14,16, 17,19
Y	US 6 428 483 B1 (CARLEBACH EPHRAIM) 6 August 2002 (2002-08-06) column 2, lines 38-65 column 6, line 28 - column 11, line 29	20,21

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO2005/000131

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 1-11
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery

2. [ ] Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/NO2005/000131

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 4269194	A	26-05-1981	NONE			
US 6428483	B1	06-08-2002	IL	130371	A	01-06-2004
			AU	5243600	A	28-12-2000
			EP	1237477	A2	11-09-2002
			WO	0074631	A2	14-12-2000
			JP	2003532442	T	05-11-2003
			US	2002082511	A1	27-06-2002

patsnap

专利名称(译)	用于估计受到体外循环的患者的paco2值的方法和装置		
公开(公告)号	[EP1742571A1](#)	公开(公告)日	2007-01-17
申请号	EP2005737637	申请日	2005-04-20
[标]申请(专利权)人(译)	RIKSHOSPITALET与Radiumhospitalet HF		
申请(专利权)人(译)	RIKSHOSPITALET，与Radiumhospitalet HF		
当前申请(专利权)人(译)	Rikshospitalet-与Radiumhospitalet HF		
[标]发明人	PEDERSEN TORE H KRISTIANSEN FRODE HGETVEIT JAN OLAV		
发明人	PEDERSEN, TORE, H. KRISTIANSEN, FRODE HØGETVEIT, JAN, OLAV		
IPC分类号	A61B5/083 A61B5/00 A61B5/08 A61M1/16 A61M1/36		
CPC分类号	A61M1/367 A61B5/14557 A61M1/1698 A61M2230/202		
代理机构(译)	BRIDDES，SAM		
优先权	20041611 2004-04-20 NO		
外部链接	Espacenet		

摘要(译)

本发明涉及一种用于通过氧合器估计体外循环患者的PaCO2值的方法和装置。该方法包括使用布置在氧合器中的温度传感器测量氧合器的废气中的PexCO 2值和患者的动脉血温值Ta的步骤。然后基于测量的PexCO2值和动脉温度测量计算估计的PaCO2值。有利地，在计算中使用从预定数量的最近PexCO2值确定的平均值。通过向PexCO2值添加校正项来执行计算，PexCO2值由温度相关分量和偏移分量组成。校正项可以由用户调整。估计的PaCO2值显示在显示器上。开关可在pH-stat模式和alpha-stat模式之间轻松更改。