



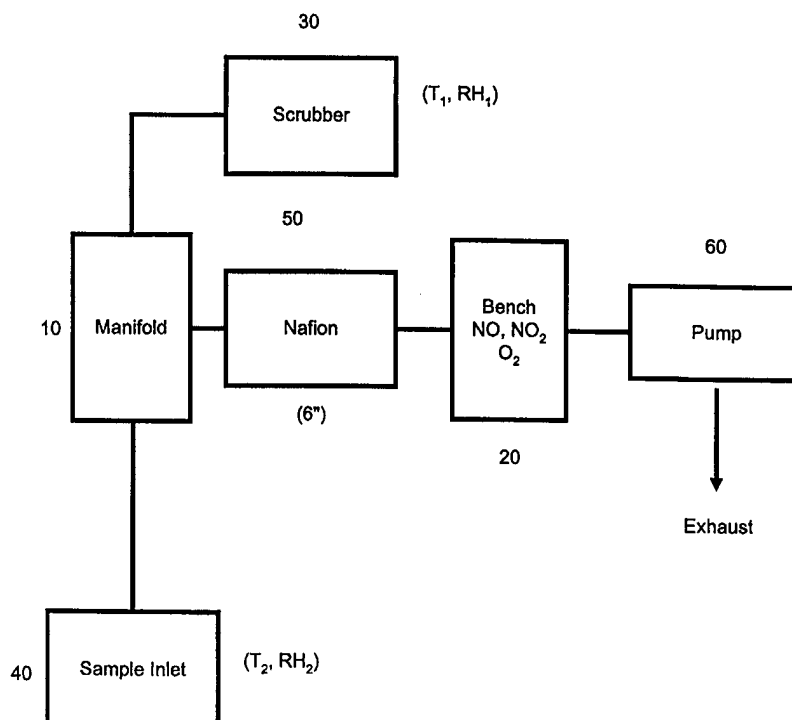
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : A61L	A2	(11) International Publication Number: WO 98/46277 (43) International Publication Date: 22 October 1998 (22.10.98)
(21) International Application Number: PCT/US98/06254 (22) International Filing Date: 30 March 1998 (30.03.98) (30) Priority Data: 60/043,250 16 April 1997 (16.04.97) US (71) Applicant (for all designated States except US): OHMEDA, INC. [US/US]; 110 Allen Road, Liberty Corner, NJ 07938-0804 (US). (72) Inventor; and (75) Inventor/Applicant (for US only): GULL, Kathleen, Bergeron [US/US]; 990 Harrison Avenue, Santa Clara, CA 95959 (US). (74) Agents: FISCHMANN, Kent, A. et al.; Holme Roberts & Owen LLP, Suite 4100, 1700 Lincoln Street, Denver, CO 80203 (US).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>Without international search report and to be republished upon receipt of that report.</i>

(54) Title: HUMIDITY COMPENSATION FOR FUEL CELL ZEROING IN RESPIRATORY GAS MEASUREMENT

(57) Abstract

The accuracy of respiratory gas measurements taken by electrochemical fuel cells is affected by changes in humidity. Such changes come more apparent after a monitoring bench containing fuel cells has been zeroed and then returned to the sampling mode where as measurement is taken of a respiratory gas sample. The difference in humidity between the sampling gas stream and the zeroing gas stream causes a zero drift in the fuel cell readings. A piece of Nafion® tubing is used after the pneumatics manifold which switches between the two gas streams and the fuel cell bench in order to equilibrate the humidity in both the sample and zero gas streams.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon	KR	Republic of Korea	PL	Poland		
CN	China	KZ	Kazakstan	PT	Portugal		
CU	Cuba	LC	Saint Lucia	RO	Romania		
CZ	Czech Republic	LI	Liechtenstein	RU	Russian Federation		
DE	Germany	LK	Sri Lanka	SD	Sudan		
DK	Denmark	LR	Liberia	SE	Sweden		
EE	Estonia			SG	Singapore		

HUMIDITY COMPENSATION FOR FUEL CELL ZEROING IN RESPIRATORY GAS MEASUREMENT

BACKGROUND OF THE INVENTION

In respiratory gas monitors electrochemical fuel cells are used in conjunction
5 with additional circuitry to measure the amount of a specific gas within a respiratory
gas stream. For example, in a monitor for measuring the concentration of nitric oxide
and nitrogen dioxide electrochemical fuel cells are used to generate an electrical signal
indicative of the respective concentrations of nitric oxide and nitrogen dioxide. Such
a monitor is useful during the administration of nitric oxide to a patient for medical
10 purposes. For example, see United States Patent No. 5,485,827, Zapol et al., which
discusses the method of treating patients with nitric oxide and United States Patent
No. 5,558,083, Bathe et al., which discloses a nitric oxide delivery system of which a
gas monitor is one element.

15 SUMMARY OF THE INVENTION

The accuracy of respiratory gas measurements taken by electrochemical fuel
cells is affected by changes in humidity. Such changes come more apparent after a
monitoring bench containing fuel cells has been zeroed and then returned to the
sampling mode where a measurement is taken of a respiratory gas sample. The
20 difference in humidity between the sampling gas stream and the zeroing gas stream
causes a zero drift in the fuel cell readings. A six inch piece of Nafion® tubing is
used in the present invention after the pneumatics manifold which switches between
the two gas streams and the fuel cell bench in order to equilibrate the humidity in both
the sample and zero gas streams. The addition of this Nafion® tubing eliminates the
25 zero drift between the two gas sources allowing for an accurate zeroing of the nitrogen
oxide and nitrogen dioxide fuel cells.

One of the problems associated with respiratory gas monitors is the excess
humidity in the sample gas stream. United States Patent No. 5,042,500 to Norlien et
al. discloses the use of Nafion® tubing placed between the patient and a respiratory gas
30 monitor to dry the exhaled breath of patient. However, this does not eliminate the
zeroing problem described above which is due to discrepancies in humidity between
the sample gas (exhaled breath) and the zero gas streams.

Therefore, it is an object of this invention to provide for a novel apparatus and method for the removal of humidity differences between the sample and zero gas streams in order to reduce or eliminate monitoring inaccuracies due to zero drift.

BRIEF DESCRIPTION OF THE DRAWINGS

5 Fig. 1 is a diagram of the gas stream flow components of a respiratory gas monitor according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 depicts the major components of a respiratory gas monitor according to the present invention through which the sample and zero gases flow. The
10 pneumatic manifold 10 controls the source of the gas stream input to the bench 20 containing the electrochemical fuel cells for the measurement of nitric oxide, nitrogen dioxide and oxygen. The manifold 10 enables the monitor control to select between inputting a sample of the respiratory gas stream into the sample inlet 40 or a sample of a calibration gas into scrubber 30. A Nafion® tube or other hydrophilic tube 50 is
15 placed between manifold 10 to bench 20 to reduce the amount of moisture in the gas stream. Vacuum pump 60 provides the Vacuum necessary to draw the sample or calibration (zeroing) gases through the system.

A series of tests was conducted using a respiratory gas monitor having electrochemical cells for the measurement of nitric oxide, nitrogen dioxide and
20 oxygen. Differing amounts of Nafion® tubing were placed between the scrubber 30 and the manifold 10 and the relative humidity of the gas was measured on the opposite side of the bench 20 as set forth in the table below:

Amount of Tubing (inches)	0	4	6	10
Relative Humidity	22.1	19.9	18.7	18.5

25

Table 1

It appears from the table above that there is an increase in drying efficiency with an increase in the length of the Nafion tubing placed after the scrubber. However the gas concentrations measured by the cells did not change appreciably with the

change in relative humidity in this dry gas sample. Therefore, there is no advantage to adding Nafion to the scrubber side of the system.

The next configuration tested used humidified sample gas and dry room air gas. The system was zeroed in each of four configurations: (1) no Nafion; (2) 4 inches of Nafion; (3) 6 inches of Nafion; and (4) 16 inches of Nafion. After zeroing the system was switched to humid sample gas and the variance in the relative humidity of the gas readings taken on the far side of the bench was recorded as set forth in the following Table 2.

Nafion Tubing (inches)	Relative Humidity Ambient Air	Relative Humidity Sample Gas	NO/NO ₂ /O ₂ Cell values (PPM/PPM/%)
0	22.1	45.4	0.0/0.2/20.7
4	20.1	45.4	0.0/0.3/20.7
6	19.5	45.5	0.0/0.3/20.7
16	19.7	45.6	0.0/0.3/20.6

Table 2

These readings show that the difference in humidity between the sample side and the room air side affects the cell readings. Although the Nafion appeared to be working on the sample side because the original gas entering the sample line had a relative humidity of about 85% it did not reduce the humidity level in that line to that of ambient. The nitrogen dioxide and the oxygen cells were more susceptible to the swing in humidity than the NO cell. In view of this experimental data it can be seen that the use of Nafion tubing at the scrubber does not solve the problem of humidity in the system.

Six inches of Nafion tubing was placed in front of bench 20 after the manifold 10. This length was chosen because it was minimally difficult to package and the prior test showed no marked improvement for much longer lengths of tubing. The system was then switched to a dry sample line and, thereafter, a humidified sample line resulting in the following:

	Ambient Air Side Relative Humidity	Sample Gas Side Relative Humidity	NO/NO ₂ /O ₂ Cell Values (PPM/PPM/%)
Dry Gas	19.9	19.2	0.0/0.0/20.8
Humidified Gas	19.9	32.1	0.0/0.1/20.6

Table 3

Thus, six inches of Nafion tubing in front of the bench nearly eliminates the drift
5 phenomenon. Although it does not completely eliminate the difference in relative
humidity between the sample side of the system and the ambient air side of the
system, the differences are lower than previously measured.

I claim:

1. An apparatus for the measurement of the concentration of a predetermined respiratory gas in a respiratory gas sample comprising:
 - a respiratory gas sample inlet for inputting said respiratory gas sample;
 - 5 a scrubber for inputting a calibration gas;
 - a respiratory gas measurement bench for measuring the concentration of said predetermined respiratory gas in said respiratory gas sample or said calibration gas;
 - a manifold for selecting between input of a portion of said respiratory gas sample or a portion of said calibration gas into the respiratory gas measurement
 - 10 bench;
 - a means between said manifold and the respiratory gas measurement bench for reducing the difference in humidity between said portion of said respiratory gas sample and said portion of said calibration gas sample.
2. The apparatus of Claim 1 wherein said means for reducing the
- 15 difference in humidity comprises a length of tubing made from a hydrophilic material.
3. The apparatus of Claim 2 wherein the length of tubing is made from Nafion(R).
4. The apparatus of Claim 2 wherein the length of tubing is approximately six inches.
- 20 5. The apparatus of Claim 1 further comprising a vacuum pump for drawing either of said portion of said respiratory gas sample or said portion of said calibration gas through the respiratory gas measurement bench.
6. The apparatus of Claim 1 wherein said predetermined gas sample is nitric oxide.
- 25 7. The apparatus of Claim 1 wherein said predetermined gas sample is nitrogen dioxide.
8. A method of measuring the concentration of a predetermined respiratory gas in a respiratory gas sample comprising:
 - placing a respiratory gas sample onto a sample inlet;
 - 30 placing a calibration gas into a scrubber;
 - selecting between input of a portion of said respiratory gas sample and said calibration gas into a respiratory gas measurement bench;

equilibrating the humidity present in said selected portion of said respiratory gas sample or said calibration gas sample prior to input of said selected portion into said respiratory gas measurement bench;

5 measuring the concentration of said predetermined respiratory gas in said selected portion using said respiratory gas measurement bench.

9. The method of Claim 8 wherein said controlling step comprises flowing said selected portion through a length of tubing made from a hydrophilic material.

10 10. The method of Claim 9 wherein said length of tubing is made from Nafion(R).

11. The method of Claim 9 wherein said length of tubing is approximately six inches.

12. The method of Claim 8 wherein said predetermined gas is nitric oxide or nitrogen dioxide.

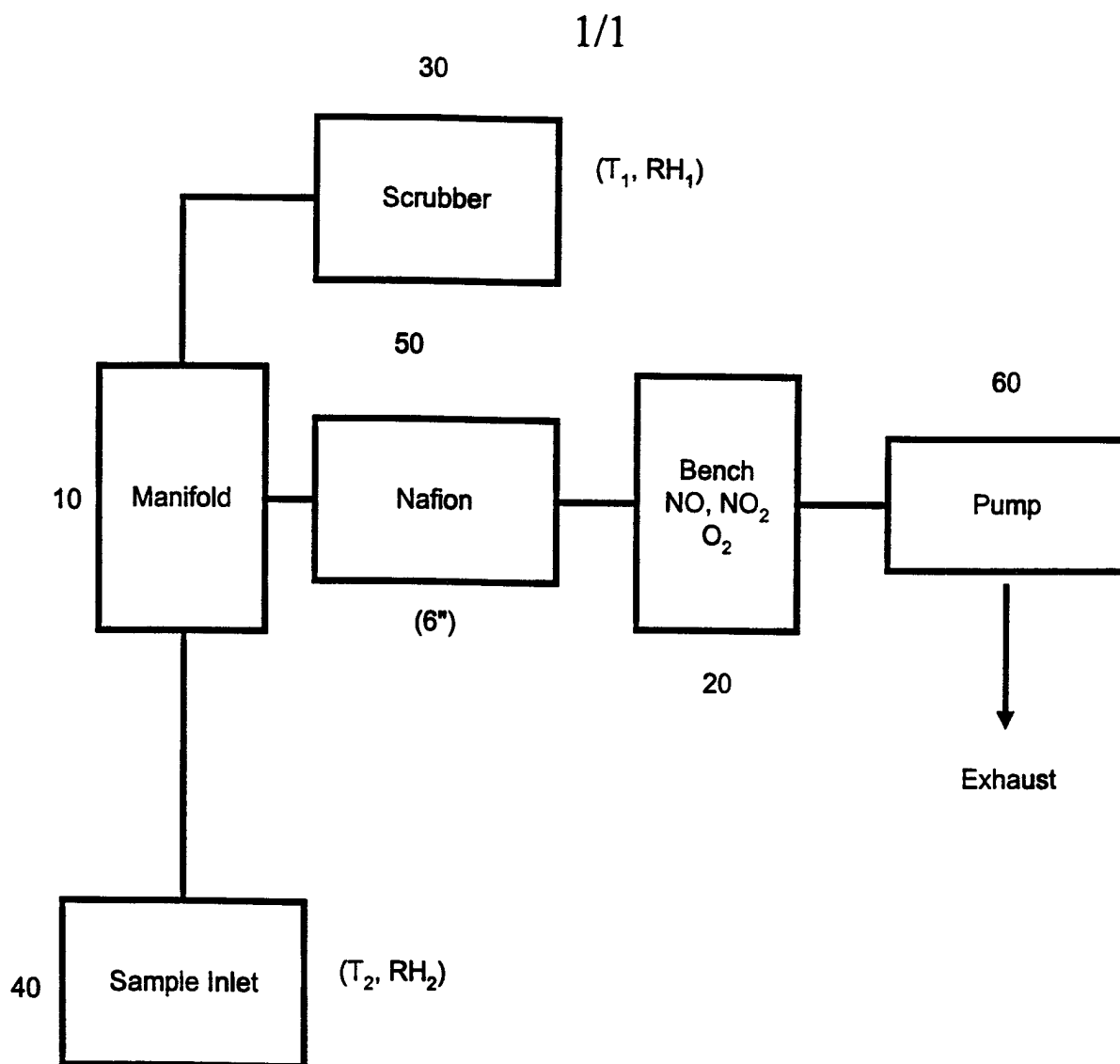


FIG. 1

SUBSTITUTE SHEET (RULE 23)