*Journal of Thermal Analysis and Calorimetry, Vol. 71 (2003) 7–11*

# THE ROOTS OF VACUUM MICROBALANCE TECHNIQUES AND THE INTERNATIONAL CONFERENCES ON THIS SUBJECT

*S. A. A. Jayaweera* [1*] *and E. Robens* [2]

[1]School of Science and Technology, University of Teesside, Middlesbrough TS1 3BA, UK
[2]Institut für Anorganische Chemie und Analytische Chemie der Johannes Gutenberg-Universität, Duesbergweg 10–14, D-55099 Mainz, Germany

**Keywords:** balance, conference, gravimetry, history, vacuum

The balance is one of the earliest measuring instruments of mankind. The oldest balance beam, found in Upper Egypt and exhibited in the Petrie Museum in London, is attributed to the Amratic period (Negade II) B. C. 3000. A wall painting of a standardisation table containing two balance beams and sets of weights and cups was discovered in the tomb of Hesi-re near the Saqqarah pyramids and can be dated rather exactly to B.C. 2650.

The history of vacuum techniques, beginning with Evangelista Torricelli and Otto von Guericke covers about 370 years. First in 1861 a kilogram vacuum balance was constructed by Delieul in order to define the mass standards of the newly introduced metric system excluding buoyancy. However, experiments of Henri Victor Regnault were to no avail because of sorption effects.

Thermogravimetric techniques were first applied to determine the water content of raw silk in 1833 by Talabot at Lyon. The first vacuum microbalances, already with electromagnetic force compensation, are from G. Urbain and Friedrich Emich, presented both in 1912. Emich constructed also the first helical spring vacuum balance. Propositions for further improvements of vacuum microbalances were developments in the field of electronics, magnetic materials and high-vacuum techniques. Following this an increasing interest in microgravimetry was developed by investigations of the reaction of solids with the gas phase (adsorption, desorption, chemisorption, heterogeneous catalysis) and some analytical methods such as thermogravimetry, surface structure analysis by adsorption, density determination, the measurement of surface tension and of the magnetic susceptibility. Thus, during the 1950s and 1960s many sorption and thermomicrobalances were developed: spring balances, electronic compensating beam balances, magnetic suspension balances and quartz resonators.

It was not only necessary to adapt the balance to the vacuum technique, but the vacuum apparatus had also to be modified for the requirements of the incorporated highly sensitive force transducer. Many disturbances (mechanical vibrations, thermally induced

* Author for correspondence: E-mail: s.a.a.jayaweera@tees.ac.uk

*1418–2874/2003/ $ 20.00*
*Akadémiai Kiadó, Budapest*

gas flow, contaminating vapours from the vacuum pump and other parts of the apparatus, leaks, magnetic and electrical influences) together with the sophisticated microbalance techniques gave rise to the desire for a forum for discussions. Furthermore, it was considered desirable that the widely scattered literature on this topic should be gathered. Thus, the Conferences on Vacuum Microbalance Techniques were started in 1960 by K. H. Behrndt, W. E. Boggs, C. N. Cochrane, A. W. Czanderna, J. Efimenko, E. A. Gulbransen, R. D. Hampson, J. M. Honig, B. C. Johnson, O. M. Katz, S. Kosiba, A. D. Magnuson, D. B. Medved, T. N. Rhodin, P. M. Rodriguez, R. Schwoebel, R. F. Walker, S. P. Wolsky, E. Zdanuk and A. C. Zettelmoyer. Since that time, ad-hoc conferences were organised by interested participants, without sponsorship by a scientific society or an interested commercial enterprise (Table 1).

**Table 1** Conferences on Vacuum Microbalance Techniques. (For abbreviations see the list at the end of the References)

| # | Year | Place | Organiser | Proceedings |
|---|---|---|---|---|
| 1 | 1960 | Fort Monmouth, NJ, USA | M. J. Katz | M. J. Katz (Ed.), VMT, Vol. 1, 1961 |
| 2 | 1961 | Washington, DC, USA | R. F. Walker | R. F. Walker (Ed.), VMT, Vol. 2, 1962 |
| 3 | 1962 | Los Angeles, CA, USA | K. H. Behrndt | K. H. Behrndt (Ed.), VMT, Vol. 3, 1963 |
| 4 | 1964 | Pittsburgh, PA, USA | P. M. Waters | P. M. Waters (Ed.), VMT, Vol. 4, 1965 |
| 5 | 1965 | Princeton, NJ, USA | K. H. Behrndt | K. H. Behrndt (Ed.), VMT, Vol. 5, 1966 |
| 6 | 1966 | Newport Beach, CA, USA | A. W. Czanderna | A. W. Czanderna (Ed.), VMT, Vol. 6, 1967 |
| 7 | 1968 | Eindhoven, Netherlands | C. H. Massen, J. A. Poulis | C. H. Massen, H. van Beckum (Eds), VMT, Vol. 7, 1970 |
| 8 | 1969 | Wakefield, MA, USA | A. W. Czanderna | A. W. Czanderna (Ed.), VMT, Vol. 8, Plenum, New York 1971 |
| 9 | 1970 | Berlin, Germany | Th. Gast, E. Robens | Th. Gast, E. Robens (Eds), PVMT, Vol. 1, 1972 |
| 10 | 1972 | Uxbridge, UK | S. C. Bevan, S. J. Gregg, N. D. Parkyns | S. C. Bevan, S. J. Gregg, N. D. Parkyns (Eds), PVMT, 1973 |
| 11 | 1973 | New York, NY, USA | A. W. Czanderna | A. W. Czanderna (Ed.), JVST 11 (1974) 396–439 |
| 12 | 1974 | Lyon, France | C. Eyraud, M. Escoubes | C. Eyraud, M. Escoubes (Eds), PVMT, Vol. 3, 1975 |
| 13 | 1975 | Philadelphia, PA, USA | W. Kollen | W. Kollen (Ed.), JVST 13 (1976) 541–560 |

**Table 1** Continued

| # | Year | Place | Organiser | Proceedings |
|---|---|---|---|---|
| 14 | 1976 | Salford, UK | D. Dollimore | D. Dollimore (Ed.), TA 24 (1978) 204–431 |
| 15 | 1977 | Boston, MA, USA | P. Ficalora | P. Ficalora (Ed.), JVST 15 (1978) 745–821 |
| 16 | 1978 | Kiel, Germany | O. T. Sørensen, H.-J. Seifert | O. T. Sørensen (Ed.), TA 29 (1979) 198–360 |
| 17 | 1979 | New York, NY, USA | A. W. Czanderna | A. W. Czanderna (Ed.), JVST 17 (1980) 90–124 |
| 18 | 1981 | Antwerpen, Belgium | R. de Batist, A. van den Bosch | E. Robens (Ed.), TA 51 (1981) 1–95 |
| 19 | 1982 | Baltimore, MD, USA | R. Vasovsky | R. Vasovsky (Ed.), JVST 20 (1983) |
| 20 | 1983 | Plymouth, UK | S. A. A. Jayaweera | S. A. A. Jayaweera (Ed.), TA (1984) |
| 21 | 1985 | Dijon, France | N. Gérard | N. Gérard, S. A. A. Jayaweera (Eds), TA 103 (1986) |
| 22 | 1987 | Rabat, Morocco | L. Belkbir | L. Belkbir, S. A. A. Jayaweera (Eds), TA 152 (1989) |
| 23 | 1989 | Middlesbrough, UK | S. A. A. Jayaweera | W. Hemminger, S. A. A. Jayaweera, E. Robens (Eds), TA 1993/94 |
| 24 | 1991 | Hammamet, Tunisia | M. Jemal | W. Hemminger, M. Jemal, E. Robens, (Eds), TA 1993/94 |
| 25 | 1993 | Siegen, Germany | J. U. Keller, E. Robens | J. U. Keller, E. Robens (Eds), VMT'94 |
| 26 | 1995 | Marrakech, Morocco | M. Ben Chanaa | M'bark Ben Chanaa (Ed.), VMT'95 |
| 27 | 1997 | Lublin, Poland | P. Staszczuk | P. Staszczuk (Ed.), JTAC 1999 |
| 28 | 1999 | Kyiv, Ukraine | V. A. Tertykh | V. A. Tertykh (Ed.), JTAC 2001 |
| 29 | 2001 | Middlesbrough, UK | S. A. A. Jayaweera | S. A. A. Jayaweera, E. Robens (Eds) |
| 30 | 2003 | Rabat, Morocco | L. Belkbir, H. Barkia | JTAC 2004 (Publication is under discussion) |
| 31 | 2005 | Wrocław, Poland | G. W. Chądzyński | |
| 32 | 2007 | Izmir, Turkey | D. Balköse | |

During the 1972 Conference, a Steering Committee was formed to provide continuity, with A. W. Czanderna and E. Robens as co-chairman. Since 1970, the conferences were organised alternatively in Europe and the USA. At the 20th Conference at Plymouth (which was planned to be definitively the last one [1]) Al Czanderna retired; upto that time the conferences were organised alternatively in Europe and Northern Africa. Following the 29th Conference at Middlesbrough in 2001, S. A. A. Jayaweera was elected as co-chairman and the Steering Committee re-organised as shown in Table 2.

**Table 2** Steering Committee for International Conferences on Vacuum Microbalance Techniques

**Dr. Zulfiqur Ali**, School of Science and Technology, University of Teesside, Middlesbrough TS1 3BA, UK. Tel.: +44 (0) 1642-342463 Fax: +44 (0) 1642-342401, E-mail: z.ali@tees.ac.uk
**Prof. Dr. Devrim Balköse**, Izmir Yüksek Teknoloji Enstitüsü, Mühendislik Fakültesi, Gülbahçe Köyö –Ula, Izmir, Turkey. Tel.: +90-232-498-6271, Fax: +90-498-6356, E-mail: dbalkose@likya.iyte.edu.tr
**Prof. Hassan Barkia**, Ecole Normale Supérieure, Département de Chimie, Route d'El Jadida, BP.9172 Mers Sultan, Casablanca, Morocco, Tel.: 00 212 61 20 36 01, E-mail: barkiahassan@hotmail.comProf.
**Dr. Larbi Belkbir**, Département de Chimie, Faculté des Sciences, Université Mohammed V, B.P. 1014, MA - Rabat, Morocco, Tel. +212-07-718-34/35/38/46, E-mail: lbelkbir@fsr.ac.ma
**Prof. Dr. M'barek Ben Chanaa**, Département de Chimie, Faculté des Sciences-Semlalia, Université Cadi Ayyad, B.P. S.15, MA - 40001 Marrakech, Maroc, Tel. +212-4-434649+430/526, Fax +212-4-436769
**Dr. Grzegorz W. Chądzyński** (Vice-Chairman), Ul. Cincaly 12/3, PL - 50-306 Wrocław 2, Institute of Physics, Wroclaw University of Technology, 50-370 Wroclaw, ul.Wybrzeze Wyspianskiego 27, Poland, Tel. +48(71) 320-25-79, Fax: +48(71)328-36-96, E-mail: ec.wa@arch.pwr.wrpc.pl
**Prof. Dr. Th. Gast**, Bergstr. 1, D-14109 Berlin, Germany. Tel.:+49-030-8051905
**Dr. S. Amarasiri A. Jayaweera** (Chairman), School of Science and Technology, University of Teesside, Middlesbrough TS1 3BA, UK. Tel.: +44 (0) 1642-342466 (direct), -342499 (School of Science & Technology), -218121 (University of Teesside), Fax: +44 (0) 1642-342401, E-mail: s.a.a.jayaweera@tees.ac.uk
**Prof. Dr. Mohamed Jemal**, Département de Chimie, Faculté des Sciences, Campus Universitaire, TN-1060 Tunis, Tunisie, Tel.: +216-1-512600, Fax: 216-1-500666
**Prof. Dr. Jürgen U. Keller**, Institut für Fluid- und Thermodynamik, Universität Siegen, D-57068 Siegen, Germany. Tel.: +49-271-7404651, Fax +49-271-7402360, E-mail: keller@ift.maschinenbau.uni-siegen.de
**Dr. ir. Carel H. Massen**, Faculty of Technical Physics, Technical University Eindhoven, Postbus 513, NL - 5600 MB Eindhoven, The Netherlands, Tel. +31402-420498, Fax +3140-447035, E-mail: c.h.massen@phys.tue.nl
**Prof. Dr. Johannes A. Poulis**, Faculty of Technical Physics, Technical University Eindhoven, Postbus 513, NL - 5600 MB Eindhoven, The Netherlands, Tel. +31402-420498, E-mail: hannespoulis@hotmail.com
**Erich Robens** (Chairman), Schlesierstr. 5, D-61381 Friedrichsdorf, Germany. Tel.: +49-06172-778584, Fax: +49-06172-777070, e-mail: erich.robens@t-online.de
**Prof. Dr. Piotr Staszczuk** (Vice-Chairman), Uniwersytet Maria Curie-Sklodowska, Wydzial Chemii, Zaklad Chemii Fizycznei, Pl. Marii Curie-Sklodowskiej 3, PL - 20032 Lublin, Poland, Tel.: +48-81-5375646, Fax:+48-81-5333348, E-mail: piotr@hermes.umcs.lublin.pl
**Prof. Dr. Valentin A. Tertykh**, Institute of Surface Chemistry, Ukrainian Academy of Science of Ukraine, Prospect Nauki 31, 252022 Kyiv, Ukraine, Tel. +380-44-2656520, Fax +380-44-UA-2640446, e-mail: tertykh@public.ua.net

A comprehensive survey of the history of development of electromagnetic balances and in particular of vacuum balances is documented in the proceedings of the conferences (Table 1). The more important papers presented at the conferences were published in the proceedings, forming treatises on vacuum microgravimetry [2–7].

## References

1 E. Robens and A. W. Czanderna, Thermochim. Acta, 51 (1981) 1.
2 S. P. Wolsky and E. J. Zdanuk (Eds), Ultra Micro Weight Determination in Controlled Environments, Interscience, New York 1969.
3 A. W. Czanderna and S. P. Wolsky (Eds), Microweighing in Vacuum und Controlled Environments, Elsevier, Amsterdam 1980.
4 R. Sh. Mikhail and E. Robens: Microstructure and Thermal Analysis of Solid Surfaces. Wiley, Chichester 1983.
5 C. Lu and A. W. Czanderna (Eds), Applications of Piezoelectric Quartz Crystal Microbalances. Elsevier, Amsterdam 1984.
6 Th. Gast, T. Brokate and E. Robens, Vakuumwägung. In: M. Gläser, M. Kochsiek (Hrsg.), Massebestimmung. VCH-Verlag, Weinheim 1996, S. 294–399.
7 Th. Gast, T. Brokate and E. Robens, Vacuum weighing. In: M. Gläser, M. Kochsiek (Eds), Comprehensive Mass Metrology, Wiley-VCH, Berlin 2000.

JTAC: Journal of Thermal Analysis and Calorimetry, Kluwer Academic Publishers, Dordrecht & Akadémiai Kiadó, Budapest, ISSN 1418-2874.
JVST: Journal of Vacuum Science and Technology, American Institute of Physics, New York.
PVMT: Progress in Vacuum Microbalance Techniques, Vol. 1–3, Heyden, London 1972–1975. ISBN 0 85501 073 8.
TA: Thermochimica Acta, Elsevier, Amsterdam. ISSN 0040–6031.
VMT: Vacuum Microbalance Techniques, Vol. 1–8, Plenum Press, New York 1961–1971. SBN 306-38408-6.
VMT'94: J. U. Keller, E. Robens (Eds), Vacuum Microbalance Techniques '94, Multiscience Publishing, Brentwood 1994, ISBN 3-527-29352-3.
VMT'95: M'bark Ben Chanaa (Ed.), Proceedings of the XXVI$^{th}$ International Conference on Vacuum Microbalance Techniques. Faculté des Sciences Semlalia, Université Cadi Ayyad, Marrakech 1995.