Notes from the Oesper Collections

The Bunge Short-Beam Balance

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By the first half of the 19th-century the best chemical balances were routinely able to detect as little as a tenth of a milligram (10^{-4} grams). In order to ensure this level of sensitivity the theory of balance design, as formalized by the Swiss mathematician, Leonhard Euler (figure 1), in 1738 (1), dictated that the balance beam should be made as long as possible so that even a slight tilt of the beam would translate into a substantial deflection of the pointer. This injunction, however, was limited by two further considerations: in order to minimize the friction at the pivot point, the beam should be made as light as possible; and in order to prevent distortion, the beam should be stiff enough to resist bending under the applied load.

Attempts to simultaneously optimize all three of these often conflicting directives resulted in an early 19th-century form of the analytical balance that was short in height and which sported a long delicate brass beam in which most of the metal had been cut away so as to make it as light as possible consistent with the required mechanical rigidity. A typical, albeit rather late, example of such a "long-beam" balance found in the Jensen-Thomas Apparatus Collection is shown in figure 2. It was made by the American firm of Christopher Becker and Sons of New York and probably dates from around 1860. Earlier, and far more extreme, examples are shown in the monographs by Child, Stock, and Jenemann (2-4).

Figure 1. Leonhard Euler (1707 -1783).

Figure 2. A Becker long-beam balance, c. 1860 (Jensen-Thomas Apparatus Collection).

One of the great disadvantages of the long-beam balance was that it took an ungodly long time for it to stop oscillating – a problem which led to the practice of "counting swings" (i.e. determining that the instrument was balanced by observing whether the pointer had swung an equal number of divisions to the left and right of the scale board rather than waiting for it to come to a complete stop). In an attempt to minimize this problem (later solutions would include air dampers and magnetic dampers), the German engineer, Paul Bunge (1839-1888), would revolutionize balance design through his introduction in 1866 of the first "short-beam" analytical balance.

Bunge, who had specialized in the design of bridges, was convinced that the conventional wisdom concerning the design of beams for highly sensitive analytical balances was wrong. In direct contradiction to earlier designs, he chose to make the beams of his balances quite short. This not only cut down on the equilibration times as he had hoped, but also allowed one to minimize the weight of the beam. In order to maintain detectability, Bunge also chose to make the

Figure 3. A Bunge style short-beam balance made by Sartorius, c. 1875 (Jensen-Thomas Apparatus Collection).

balance pointer extra long. As a consequence, the resulting "short-beam" balances – in direct contrast to the older "long-beam" balances – were tall and narrow in appearance rather than short and wide. Although the Jensen-Thomas Collection does not own 19th-century example of a balance manufactured by Bunge's own firm, a photo of his first balance of 1866 may be found in reference 2, and the website for the Avery Museum of Balances in Great Britain also contains photos of several later versions (5).

Other balance manufacturers soon adopted Bunge's innovations and the term "Bunge balance" is often applied to short-beam balances in general whether or not they were manufactured by Bunge's own company. One such imitator was the firm of Florenz Sartorius of Göttingen, who began producing short-beam balances in 1870 and who introduced the further innovation of replacing the traditional brass beam with much lighter beams made of aluminum. The Jensen-Thomas Collection owns a Sartorius "short-beam" balance (figure 3) dating from roughly 1875 which has an acid-proof black glass base and a ratchet rather than a counterweight system for lifting the front door. It also uses a plumb-line rather than a spirit level to indicate when the balance platform is level.

More recently the collection has acquired a second short-beam balance (figure 4), which sports a cast-iron rather than a wooden case, and which indicates on the scale board that it was sold by Queen & Company of Philadelphia. However, it is almost certain that this balance was made for, and not by, Queen & Company (6). The characteristic triangulated aluminum short-beam with the centralized adjustment screw and gravity bob, the pan arrest mechanism, and the peaked extension of the door, which would normally carry the name of the maker – aspects of which are found in various degrees in the balance in figure 3 and in the 1876 balance on display in the Science Museum in London and shown in reference 3 – all suggest that this balance was instead made for Queen & Company by Sartorius of Germany.

The balances in figures 2-3 are but a few of the more than 50 chemical balances found in the Oesper Apparatus Museum and are indicative of the richness and variety of our artifacts.

Figure 4. A recently acquired Bunge style short-beam analytical balance with a cast-iron case, black-glass base, and triangulated aluminum beam, circa 1885 (Jensen-Thomas Apparatus Collection).

References and Notes

1. L. Euler, "Disquisitio de bilancibus," *Commentarii academiae scientiarum imperialis Petropolitanae*, **1738**, *10*, 3-18.

2. E. Child, *The Tools of the Chemist: Their Ancestry and*

American Evolution, Reinhold: New York, NY, 1940, Chapter 7.

3. J. T. Stock, *Development of the Chemical Balance,* Science Museum: London, 1969.

4. H. R. Jenemann, *Die Waage des Chemikers*, DECHEMA: Frankfurt am Main, 1997.

5. The Avery Balance Museum, Website for Stanton Instruments LTD.

6. Oddly we cannot locate this balance in our copies of the catalogs for the Queen & Company (circa 1889) nor is there any indication that they sold Sartorius balances.