During his administration, the drainage and lighting systems of the city were greatly improved and work was begun on the system of aqueducts and tunnels to supply Paris with spring water. In 1870, the upheaval which brought Hugo back to France led to the resignation of Dumas from public service and his return to chemistry. He too remained active almost until his death, publishing papers on topics such as fermentation and the occlusion of oxygen in silver.

It seems to me that there are enough parallels to make a good case for Urbain's statement. Let me close with a curious twist. In *Les Miserables* there is a character called Grantaire who drinks a lot and, when in his cups, is given to eloquent flights of discourse, ranging over history, philosophy and, in at least one instance, science. In Part Four, Book XII, Chapter 3, he says (7):

> Comrades, we're going to throw out the Government and that's the truth, as true as the fact that between margaric acid and formic acid there are 15 intermediate acids. Not that I care a straw about that. My father always abominated me because I couldn't understand mathematics.

Now *Les Miserables* was written in 1862. In 1842, three years before Gerhardt coined the phrase "homologous series" for sets of compounds whose composition differed only by a multiple of CH_2, Dumas had shown that such a relation exists among fatty acids, and in his paper had affirmed that between formic and margaric acids there were exactly 15 intermediate acids, of which nine were known at that time and six remained to be found (8). Dumas, as an educated man of his time, must have almost certainly read Hugo's works and, as the above quote suggests, it seems that the converse must also be true!

References and Notes

1. G. Urbain, "Jean-Baptiste Dumas and Charles-Adolphe Wurtz", in E. Farber, ed., *Great Chemists*, Interscience Publishers, N.Y. 1961, pp. 521-33.
2. The biographical information on Dumas was obtained from two main sources: S. C. Kapoor, "Jean-Baptiste Dumas", in C. Gillespie, ed., *Dictionary of Scientific Biography*, Vol. 4, Scribner, NY, 1971, pp. 242-48; and J. W. Alsobrook, "Jean Baptiste Andre Dumas", *J. Chem. Educ.*, **1951**, *28*, 630-633.
3. There are a number of biographies of Hugo; a very readable one is M. Josephson, *Victor Hugo: A Realistic Biography of the Great Romantic*, Doubleday, NY, 1942.
4. See B. Chastain, "Books of the Chemical Revolution, Part I: Méthode de Nomenclature Chimique", *Bull. Hist. Chem.*, **1989**, *3*, 7-11.
5. Quoted in J. R. Partington, *A Short History of Chemistry*, Dover, New York, NY, 1989, p. 219.
6. For general background on the conflict between the dualistic and unitary theories see A. J. Ihde, *The Development of Modern Chemistry*, Harper, New York, NY, 1964, pp. 184-198 and reference 5, Chap. 9-11.
7. V. Hugo, *Les Miserables*, Penguin Classics, 1982, p. 928 (translation by N. Denney).
8. Quoted in reference 1, p. 527.

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VICTOR SERRIN AND THE ORIGINS OF THE CHAINOMATIC BALANCE

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With a history of thousands of years, the conventional, or two-pan, balance is known to everyone; it is the symbol of justice. Various forms of this instrument are in worldwide use, although the so-called single-pan balance and, latterly, the electronic balance, have largely displaced the two-pan version in the laboratory.

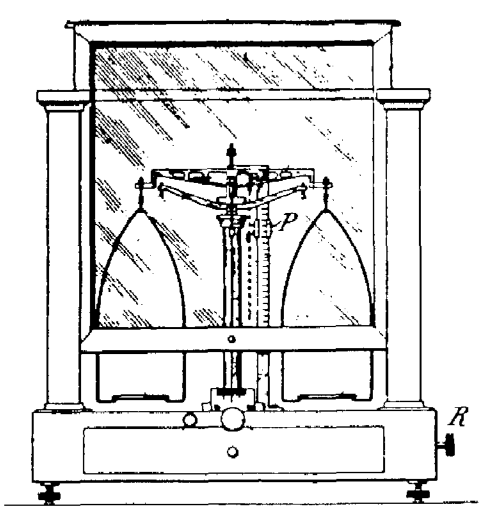
Trade in small but valuable objects, such as gemstones and gold coins, encouraged the development of the balance. Instruments of quite high sensitivity were in use by the 16th century. The introduction of regional or national standards of weights and measures further emphasized the need for precision balances, taxing the skill of 18th- and early 19th-century instrument makers such as Jesse Ramsden (1), Thomas Robinson (2), and Henry Barrow (3).

Instruments designed for chemical work are routinely expected to be able to detect a mass difference of one part in a million. For a 100-gram maximum load, this means weighing to the nearest 0.1 milligram. The results obtained in the use of even the finest two-pan balance depend ultimately upon the self-consistency and accuracy of the associated standard weights. These are added or removed by tweezers. However, very small weights are difficult to handle in this fashion and are easily lost. Conventionally, this problem is minimized by the use of a "rider" that can be suitably placed on a graduated scale on the beam of the balance. For example, a 10-milligram rider placed very near to the center knife or fulcrum of the beam could exert the same turning force as a 0.3-milligram weight that was placed directly on the balance pan. Manley (4) attributes the introduction of the principle of the rider to Berzelius. It is certain that British balance maker Ludwig Oertling received a medal for his balance "with graduated beam and sliding apparatus", shown during the 1851 Great Exhibition in London (1).

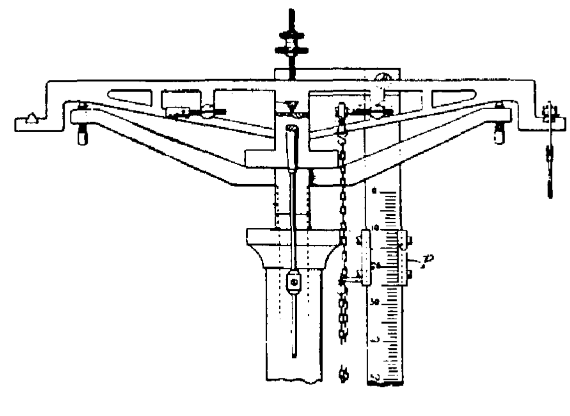
A later solution to the problem is the utilization of a fine chain. One end of this hangs from a grooved screw that is suitably mounted on the right-hand half-beam. The other end is attached to a hook on a carriage that can traverse a graduated vertical column standing just in front of the beam. An adjustable counterweight on the left-hand half beam compensates for the turning force of the chain when the carriage is at the zero mark near the top of the column. As the carriage is lowered, more of the total length of the chain exerts a turning force on the beam. Typically, the range covered by full travel of the carriage is zero to somewhat greater than 100 milligrams. In the associated box of weights, the smallest of these is one decigram.

A patent for this type of balance was granted to Christopher A. Becker in 1916 (5). The illustrations for Becker's patent show both a general view of the balance and the details of the beam. Attached to the carriage is a pin that engages a spiral groove in a vertical spindle. This can be rotated through bevel gearing by a knob on the outside of the balance case, allowing the carriage to be positioned to bring the balance to equilibrium after the case has been closed. This type of balance, known as "chainomatic", was commercialized in the United States and also by L. Oertling, Ltd. in Britain (6).

The general impression is that the chain balance originated in the United States (6-9). However, a text of 1899 (10) refers to the "Chaîne Serrin", which appears to be very similar to the arrangement described by Becker seven years later (5). In fact, the Frenchman, Victor Serrin (b. 1829), gave a concise description of the chain balance in *Comptes Rendus* as early as 1891 (11). Since he was apparently not a member of the "Academie"; his notice was presented by Janssen. Serrin's subsequent patent (12) indicates applications of the "chaîne", which he termed "pondérateur", to various measuring instruments. The figures from this patent show three versions of the



Becker's "Chainomatic" balance of 1916 (5)



Close-up of the chain mechanism for Becker's balance (5)

chain balance. The first employs a vertical carriage column, while the second has a pulley to permit horizontal travel of the carriage. In the third, the column and carriage are replaced by a graduated drum on which the chain is wound. Also shown are arrangements for measuring the force exerted by a solenoid, a Prony-brake device for mechanical forces, and a system for barometric measurements. In all cases, the chain is shown attached to one end of the beam. However, these figures are obviously diagrams and not illustrations of actual devices.

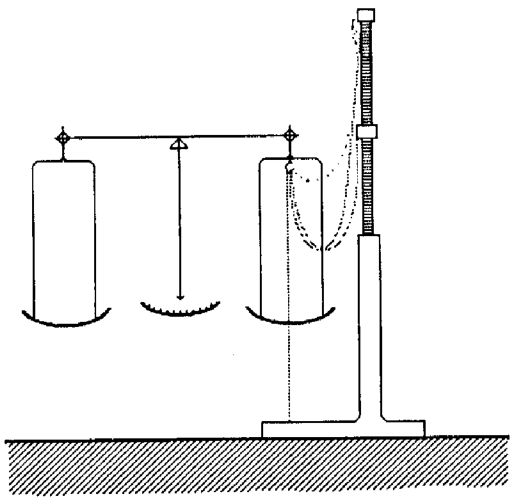
Becker's patent contains the following statement (5):

> In scales or balances having a counterbalancing chain as heretofore proposed, the adjustable or dead end of the chain has been hung to a slide having a frictional engagement with a vertical guiding part and being moved up or down by the direct manipulation by the hand of the operator... Such construction if applied to an inclosed balance would require re-opening its case for each adjustment, and the necessity for this deprives the chain type of balance of any material advantage over those requiring manual adjustment of a counterpoising weight or weights. The present invention, by providing for an adjustment of infinite nicety which admits unprecedented rapidity in counterpoising, and which in an inclosed balance may be accomplished from the exterior without opening the casing, provides a scale or balance having important practical advantages over any weighing means heretofore used.

It is true that Serrin's 1891 paper has no diagrams. However, it contains the sentence (11, 15):

> The chain is easily moved from outside of the case by means of a special button, in such a way that when a weighing has been approximated to the nearest 1 mg, it is no longer necessary to open the case to complete the operation.

The 1899 account of the "chaîne Serrin" includes the illustration of a chain-type balance carrying the inscription "A. DEMICHEL, PARIS" (10). The movement of the chain



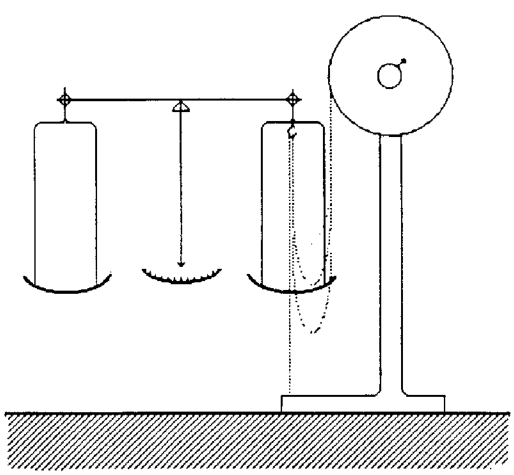
Serrin's vertical carriage design, redrawn from (12)

carriage is definitely operable from outside the case. Apparently, the chain is suspended from the beam at a point quite close to the center knife, as in the Becker balance.

A 1901-2 listing of French instrument makers (13) indicates that A. Demichel had taken over the business founded by J. Salleron in 1855. Demichel made a wide variety of physical and chemical apparatus, as well as marine and meteorological instruments.

Although the chain balance system is simple, the precise underlying theory is not. This aspect has been examined by W. Uhink, of Sartorius, a famous balance-making firm (14). He derived formulas for the calculation of errors and evolved methods for the essential elimination of these.

A need to evaluate many thousands of ancient weights led to the application of the chain principle to a massive form of balance (9). One end of the brass chain is attached to the pan that carries the standard, or modern, weights; a precision of about 10 milligrams is claimed.



Serrin's graduated drum design, redrawn from (12)

References and Notes

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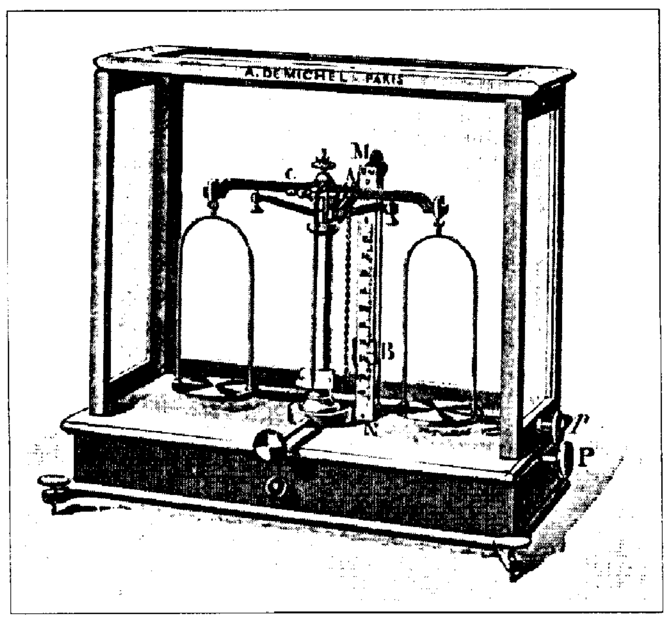
1. J. T. Stock, *Development of the Chemical Balance*, Science Museum: London, 1969, p. 12.

2. J. T. Stock, "Thomas Charles Robinson and His Balances", *J. Chem. Educ.*, **1968**, *45*, 254-257.

3. J. T. Stock, "Henry Barrow, Instrument Maker", *Bull. Sci. Instrum. Soc.*, **1986**, (9), 11-12.

4. J. J. Manley, "Balance", in E. Thorpe, ed., *A Dictionary of Applied Chemistry*; Vol. 1, Longmans, Green, London, 1921, p. 507.



A French chain balance, circa 1899 (10)

5. C. A. Becker, *Weighing Scale*, U.S. Patent 1,203,686, 7 November 1916.

6. J. J. Manley, "Balance", in J. F. Thorpe and M. A. Whiteley, eds., *A Dictionary of Applied Chemistry*, Supplement to Vol. 1, Longmans Green, London, 1934, p. 155.

7. Reference 1, p. 30.

8. F. A. Gould, "Balance", in R. Glazebrook, ed., *A Dictionary of Applied Physics*, Vol. 3, Macmillan, London, 1923, p. 118.

9. F. Petrie, "The Chain Balance", *J. Sci. Instrum.*, **1923**, *1*, 29.

10. J. A. Montpellier and M. Aliamet, *Guide Pratique de Mesures et Essais Industriels*; Vol. 1, Ch. Dunod, Paris, 1899 p. 115.

11. V. Serrin, "Nouveau système du balance de prècision à pesées rapides", *Compt. Rend.*, **1891**, *112*, 1299.

12. V. Serrin, *Pour l'application d'un dispositif a chaîne, dit pondérateur, aux instruments de pesage et de mesure de tous genres*, French Brevet 199,701, 20 July 1889.

13. *L'Industrie Francaise des Instruments, 1901-1902*, Syndicat des Constructeurs en Instruments d'Optique et de Precision, 1902, p. 244 (facsimile reprint, Alain Brieux, Paris, 1980).

14. W. Uhink," Zur Theorie und Praxis der Kettenwaage", Z. *Instrum.*, **1926**, *46*, 519.

15. La chaîne se manoeuvre facilement de l'extérieur de la cage a l'aide d'un bouton *ad hoc*, de telle facon que, lorsqu'une pesée a été ebauchée, á 1 mgr près, il n'est plus necessaire d'ouvrir la cage pour la compléter.

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LAURA ALBERTA LINTON (1853-1915): AN AMERICAN CHEMIST

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American women chemists publishing without a male coauthor in the years before 1900 form a rather select group, and if we exclude those whose only single-author publication was Ph.D. dissertation research, the number becomes even smaller (1). Of the independent workers who make up this remaining group, a few are well known in the story of women scientists in America: one might name, for instance, Ellen Swallow Richards of MIT, whose early papers in analytical chemistry (2) date back to the mid-1870s, Helen Abbott-Michael, author of several papers on the chemical identification of plant constituents (3), and Ida Keller, another plant chemist (4). However, in the early volumes of the American chemical journals there are also less well-known names, and one of these is Laura Alberta Linton.

Laura Linton published two substantial papers on the analysis of asphalt samples in the *Journal of the American Chemical Society* in 1894 and 1896 (5). The publications appearing in this journal in its early years were somewhat uneven in quality and scientific content, but the two papers by Linton stand out for the amount of careful analytical work they record and the clarity and directness of their presentation. Furthermore, we know that they were received by the chemical community with some interest, and were considered important contributions to the field. Linton says in the introduction to her second (1896) paper that she was encouraged to present more

Laura Alberta Linton

results and to indicate new developments in her analytical methods, because of the favorable reception accorded her 1894 publication. An extensive discussion followed the oral presentation of the 1896 paper at the Cleveland meeting of the American Chemical Society in December 1895, the participants clearly recognizing the commercial importance of asphalt. In 1896 Linton published one other paper (6), jointly with the petroleum chemist Stephen F. Peckham. After that her name disappears from the chemical literature.

Who was Laura Linton? She was born in Mahoning County, Ohio, 8 April 1853, the oldest child in the Quaker family of Joseph and Christiana Linton (7). The Lintons farmed in Ohio, Pennsylvania and New Jersey, and finally settled in Wabash County in southern Minnesota in 1868. Laura graduated from Winona Normal school in 1872, and enrolled at the University of Minnesota in Minneapolis the same year. Chemistry became her major interest.

In her senior year Linton was given the job of analyzing some mineral specimens collected along the northern shore of Lake Superior by two faculty members, Stephen Farnum Peckham and Christopher W. Hall. The small, translucent, green pebbles she investigated were chemically very similar to thomsonite, a silicate of calcium, sodium and aluminum, but Peckham and his co-worker concluded, mainly from differences in the crystalline structure and the unusual color, that they had found a distinct variety of thomsonite. They gave it the name *Lintonite*, "in honor of Miss Laura A. Linton, a recent graduate of this University to whose patient effort and skill we are indebted for the analysis given in this paper" (8).

Linton graduated with a B.S. from the University of Minnesota in 1879, and then taught for a year at the high school in Lake City, Minnesota. Around this time Stephen Peckham had undertaken the preparation of a report for the 1880 United States Census on the *Production, Technology and Uses of Petroleum and its Products*, and he invited Laura Linton to