

# CHARLES BABBAGE (1791-1871): The Calculating Engine

## ARCHIVED ONLINE EXHIBIT

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## INTRODUCTION

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The role of Charles Babbage (1791-1871) in the prehistory of computing has often been told. Babbage's designs for his mechanical Difference Engine and Analytical Engine pioneered many concepts used in modern computers (for instance, the distinction between the calculating engine itself and memory storage, and the creation of pre-designed programs for standard operations). This exhibit used many of the original publications in which Babbage put forward his ideas, to illustrate the range of historically-significant materials represented in the library of the antebellum South Carolina College and now available for study in the modern Department of Rare Books & Special Collections.

# CHARLES BABBAGE, THE BEGINNING

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## Babbage at Cambridge & in the Royal Society

Charles Babbage, 1791-1871.

“An Essay towards the calculus of functions,”

*Philosophical Transactions of the Royal Society*, 105 (1815): 389-423.

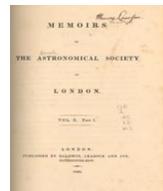
-At Peterhouse, Cambridge (1811-1814), Babbage was a brilliant undergraduate mathematician, though he was barred from competing for honors following official suspicions about his religious views. His early mathematical papers in the *Philosophical Transactions* led to his election as a Fellow of the Royal Society in 1816, when he was still only twenty-five. Later, he was elected to Sir Isaac Newton’s former chair, as Lucasian Professor of Mathematics (1828-1839), though never he never delivered a lecture.



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## The Analytical Society

Herschel, John Frederick William, 1792-1871.



“On equations of differences and their application to the determination of functions from given conditions,” extracted from *Memoirs of the Analytical Society*, Cambridge: J. Smith, 1813. Separately bound in nineteenth century calf. South Carolina College Library Collection.

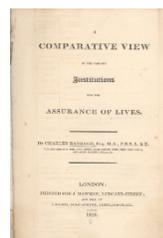
-In 1812, while still an undergraduate, Babbage founded this Cambridge-based society for mathematical research, with his friend John Herschel, son of the astronomer Sir William Herschel. Herschel and Babbage both contributed to the Society's *Memoirs*. In the 1820's, Herschel became an influential ally for Babbage’s work on the difference engine.

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## Elopement and Applied Mathematics

Charles Babbage, “An Examination of Some Questions Connected to Games of Chance,” *Transactions of the Royal Society of Edinburgh*, 9 (1821): 153-177.

And: Charles Babbage, *A comparative view of the various institutions for the assurance of lives*. London, J. Mawman, 1826. Modern calf.

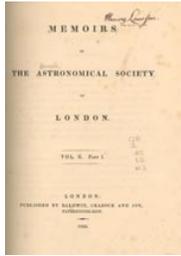


-Soon after graduation in 1814, Babbage eloped with his fiancée, Georgina Whitmore, quarreling with disapproving father, a wealthy banker. Though he still enjoyed a substantial private income, and inherited more on his father’s death, in the early years of his marriage he undertook a number of paid projects in applied mathematics, as shown here in his work for a gambling syndicate (their proposed system was not going to be a good investment) and for the new financial industry of life insurance. He also worked for banking firms and railway companies. Georgina died quite suddenly in 1827.



## The Mechanics of Astronomy and Logarithmic Tables

Charles Babbage, "On a New Zenith Micrometer,"

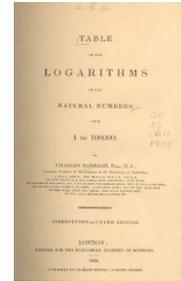


**Memoirs of the Astronomical Society**, 2 (1826): 101-103.

And: Charles Babbage,

**Table of the logarithms of the natural numbers, from 1 to 108000. Stereotyped.**

3rd ed. London: Printed for the Hungarian Academy of Sciences, 1834. Rebound.



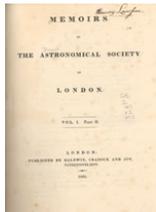
—Babbage’s involvement with the recently-founded Astronomical Society led to an interest in the mechanics of precision instruments and in the mathematical tables on which astronomers (and ocean-going navigation) depended. He first published his revised *Tables of Logarithms* in 1826, involving laborious multiple rechecking for mistakes either in the mathematics or in the printing. The stereotyping of the printed text was in part a strategy to reduce the chance of introducing fresh misprints in later printings.

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## The First Announcement of Babbage’s Difference Engine

Charles Babbage,

“A note respecting the application of machinery to the calculation of astronomical tables,”



**Memoirs of the Astronomical Society**, 1 (1822): 309.

—This modest one-page note (followed by a further three pages of “Observations” on the same topic) marks the first announcement of Babbage’s plan to produce more accurate astronomical tables, eliminating human error by turning over both the calculation and the typesetting to a machine. It was soon followed by a separate pamphlet on the same topic addressed to Sir Humphry Davy, the President of the Royal Society, whose endorsement

Babbage would need in seeking government funding for the project. The following year, in recognition of this proposal, the Astronomical Society awarded Babbage its first Gold Medal. For the full text of Babbage's note, click on the title-page image.

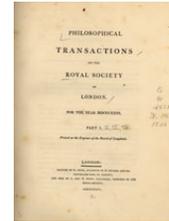
## CHARLES BABBAGE, CONTINUED

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### Designing the Difference Engine

Charles Babbage, "On a Method of Expressing by Signs the Actions of Machinery," *Philosophical Transactions of the Royal Society*, 116 (1826): 250-265.

—Babbage had, not only to envision, but to design and supervise the manufacture of his invention. Each piece had to be made and tested by hand, by skilled craftsmen working from drawings made under his supervision. In this essay Babbage described his new system of notation for indicating on the drawings how each part would move when the engine was activated.



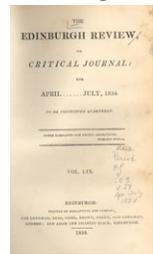
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### Dionysus Lardner on the Difference Engine

Dionysus Lardner, 1793-1839,  
"Babbage's Calculating Engine,"

*Edinburgh Review*, 59 (April 1834): 263-327.

—Manufacture of the Difference Engine took years longer than Babbage (or the government) expected, with horrendous cost-overruns. The initial grant was for L2250, yet by 1834, government expenditure had been L17,478, besides Babbage's substantial personal investment, and only 12,000 of the required 25,000 parts had been made. What was finished, in 1832, was a small demonstration section of the engine, which Babbage kept in his London house and displayed to society visitors. This article from the leading Whig periodical by a popular science journalist, Dionysus Lardner (editor of the *Cabinet Encyclopedia*), is the first detailed published description of the project.



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### Babbage and Industrial Manufacture

Charles Babbage, "On the General Principles which Regulate the Application of Machinery to Manufacture and the Mechanical Arts," *Encyclopaedia Metropolitana*, 8 (1829): 1-84.  
And: Charles Babbage,

*On the economy of machinery and manufactures.*

3d ed. enl. London, C. Knight, 1832 [i.e. 1833]. Modern red binder's cloth

—Babbage's interest in manufacturing processes led to his commission to write this substantial and very original essay. In preparation, he traveled widely visiting factories both in Britain and on the continent, analyzing the economic well as technical factors involved in industrial development. The essay was in book form in 1832, reprinted several times in Britain and America, and into four languages. As the pages displayed show, the problem of designing a calculation provided one of the model cases in his analysis.



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## Babbage on Scientific Patronage and the Royal Society

Charles Babbage,

***Reflections on the decline of science in England, and on some of its causes.***

London: B. Fellowes, 1830. Nineteenth century calf. South Carolina College Library Collection.



–In the 1820's and 1830's, British science was dominated by wealthy and aristocratic amateurs. This book, a scathing indictment of the Royal Society and its Council, played a significant role in the process by which patronage was gradually transferred from amateurs to professional scientists, but the *ad hominem* nature of Babbage's attack—his appendix, for instance, tabulates an inverse ratio for Fellows between the number of scientific publications and their length of Council service—alienated many of the senior figures whose support Babbage needed for his Engine.

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## Calculating the (Im)Probabilities of Random Creation

Babbage,

***Bridgewater treatise. A fragment.***

Murray, 1837. Later calf. South Carolina College Library.

Babbage,

***Bridgewater treatise: a fragment.***

Philadelphia: Lea & Blanchard, 1841. 1st American from the 2nd London ed. Original cloth.

–Babbage's alienation from the scientific establishment, aided by his lingering reputation as religiously unorthodox, precluded his participation in one of the major scientific boondoggles of the nineteenth century, the Bridgewater Bequest. On his death in 1829, the eccentric Right Honourable and Reverend the Earl of Bridgewater left the huge sum of £8000 to the Royal Society. The money was to fund eight eminent scientists in writing the Bridgewater Treatises, demonstrating the “power, wisdom and goodness of God” from the complexity of the natural world. In his unofficial and unfunded Ninth Treatise, Babbage used his calculating engine to calculate the probabilities of random creation.



Charles

***The ninth***

London, J.

And: Charles

***The ninth***

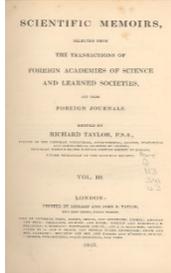


# CHARLES BABBAGE, CONCLUSION

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## Babbage's Analytical Engine

Menabrea, Luigi Frederico; Ada A. Lovelace, 1815-1852,



transl. and ed., "Sketch of the Analytical Engine," *Scientific Memoirs*, 3 (London: Taylor, 1843): 666-731.

—While the original project for his Difference Engine languished in a dispute over funding, in 1829-1830, Babbage envisioned a much more flexible, and mechanically more sophisticated, calculating machine, the Analytical Engine. This new engine was divided into two parts, the Mill and the Store (roughly the central processor and the memory), and it was to be programmed with punched cards, which were already in use on the Jacquard silk-weaving loom. In addition, it was directly linked to a mechanical output device, which could be set either to print or to impress a stereotype mould. Babbage lectured about his ideas in Turin, Italy, in 1840, and the fullest contemporary account of the Analytical Engine appeared in Italian, in 1842, with this expanded English translation the following year. The Analytical Engine was a private, not publicly-sponsored, project, and Babbage never saw it built, but many detailed plans survive, and after his death his son Henry built part of it.

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## Ada Lovelace

Anon., *Vestiges of the natural history of creation*.

London: John Churchill, 1844. Original red cloth. *C. Warren Irvin Jr. Collection*.

—The English translation of Menabrea's account was by Byron's daughter, Ada, Countess of Lovelace, who added notes derived from Babbage's Turin presentation. Ada Lovelace's reputation as an ambitious amateur scientist is evidenced by the rumours that attributed to her this anonymous bestseller *Vestiges of the Natural History of Creation*, actually by the Scottish publisher Robert Chambers.



## Babbage as Outsider: the British Association



Charles Babbage, "Short Account of a method by which Engraving on Wood may be rendered more useful for the Illustration and Description of Machinery," *Report of the Meeting of the British Association at Newcastle*(1838): 154.

—Though Babbage withdrew from participation in the Royal Society, he warmly endorsed the founding of its wider-ranging and more democratic rival, the British Association, and made a number of presentations at its meetings. Later publications in various journals dealt not only with his calculating engines, and scientific politics, but also with such varied subjects as taxation, lunar geology, life peerages, lighthouses, tides, a new ophthalmoscope, codes and code-breaking, and "The relative frequency of occurrences of the causes of breaking plate-glass windows" (*Mechanics Magazine*, 1857).

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## Babbage and the Great Exhibition

Charles Babbage,

### ***The Exposition of 1851; or, Views of the industry, the science, and the government, of England.***

London: J. Murray, 1851. Contemporary calf. South Carolina College Library Collection.

—Among those who had responded most positively to Babbage’s plans for the Analytical Engine had been Queen Victoria’s German husband, Prince Albert, so Babbage took it particularly hard when he was not invited to participate in Prince Albert’s Great Exhibition of the Industry of All Nations, in the Crystal Palace, London, in 1851. Shown here is Babbage’s book-length critique of the Exhibition, published that same year.



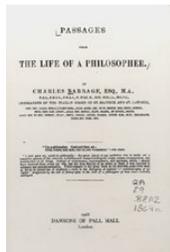
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## Babbage’s Autobiography

Charles Babbage,

### ***Passages from the life of a philosopher.***

London: Longman, Green, 1864; reprinted London: Dawsons, 1968.



—The story of Babbage and his Calculating Engines is as much human and institutional as it is mathematical or conceptual. Following the successful display of the demonstration Difference Engine at the second International Exhibition, in 1862, Babbage wrote a retrospective account of his career, in this autobiography, with this moving farewell advice to younger scientists who wished to follow in his tracks. In his will, Babbage left the drawings and remaining parts of his great project to his son Henry. After Babbage’s death, Henry, with assistance from a scientific instrument company, successfully completed a portion of the Analytical Engine, the Mill and printing mechanism, now in the Science Museum in London.

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Benjamin Woolley, *The Bride of Science:: Romance, Reason, and Byron's Daughter*. New York: McGraw-Hill, 1999.  
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The full text of Babbage's *On the economy of machinery and manufactures* is available online, at:  
<http://socserv2.socsci.mcmaster.ca/%7Eecon/ugcm/3ll3/babbage/index.html>