Charles Babbage

English inventor and mathematician **Charles Babbage** (December 26, 1792 – October 18, 1871) was one of the most original and innovative thinkers of his time. He almost deserves the title "Father of Computing" that some have hung on him. This splendid Victorian eccentric was born at a time England was rushing madly towards industrialization. Unlike his contemporary Charles Dickens, who wrote so passionately of the evils and misery brought on by the industrial revolution, Babbage saw only its promise in predicting and controlling the definite order of the universe. He was the leading advocate of the systematic application of science to industry and commerce. His interest in compiling accurate mathematical and astronomical tables led him to design a mechanical computer or "difference machine" [Figure 10.7], which would both perform calculations and print the results.

Because of practical and financial difficulties neither this machine nor a subsequent "analytical engine" [Figure 10.8] was completed. Nevertheless he is considered a computer pioneer for his contributions to the basic design of the computer through his Analytical engine, which possessed all the essential logical features of the modern general-purpose computer. There is no direct line of descent from Babbage's work to the electronic computers invented in the 1930s and 1940s as his work had been forgotten. In 1991 British scientists completed Difference Engine No. 2 built to Babbage's specifications, one month before the 200th anniversary of his birth. It weighs 2.6 tons and consists of 4000 separate parts.

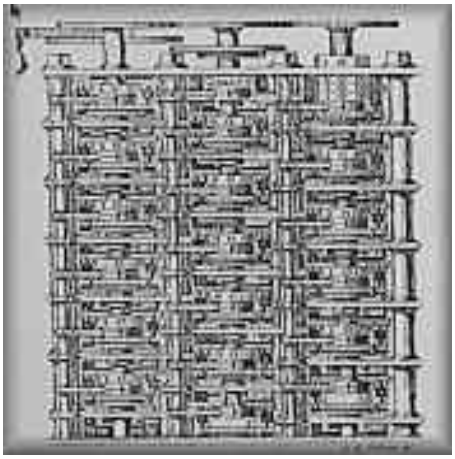

Figure 10.7

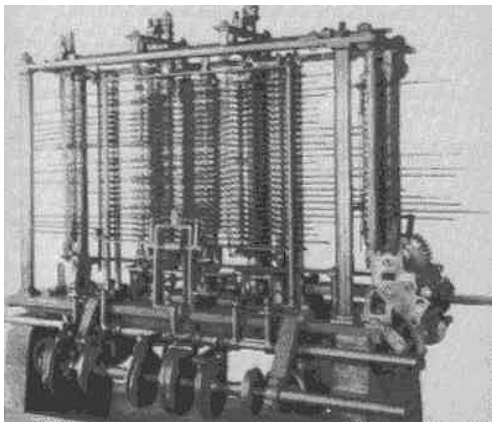

Figure 10.8

Babbage was born at Teignmouth in Devonshire, London, the son of a prosperous banker and his wife. As a child he displayed a keen interest in knowing how things worked. As he recalled, "My invariable question on receiving a new toy, was, 'Mama, what is inside it?'" At Forty Hill School in Enfield, Middlesex he showed a passion for mathematics but a dislike of the classics. He studied at home with an Oxford tutor before attending Trinity College, Cambridge, but graduated from Peterhouse in 1814 and received an MA in 1817. He found that he knew more mathematics than his teachers and concluded that English mathematics was lagging far behind Continental standards. British mathematics was still suffering from the Newton-Leibniz controversy. On the continent mathematicians used the differential notation of Leibniz for the derivative, while English mathematicians clung to Newton's clumsy fluxional notation. With George Peacock and John Herschel, Babbage established the Analytic Society, which campaigned to introduce the Leibniz notation in England to supplant that of Newton. To facilitate this the trio translated S.F. Lacroix's *Sur le calcul différentiel et intégral* into English.

Realizing that his friends were better mathematicians, Babbage didn't compete for honors at Cambridge, which led to Herschel being the first Wrangler and Peacock the second. Babbage moved to

London where he wrote two major papers on functional equations. He questioned the organization and usefulness of learned societies, criticized the unprogressive ones, including the Royal Society, to which he was elected a fellow (1816). He helped establish new ones such as the Astronomical Society (1820), the British Association (1831), and the Statistical Society of London (1834). From 1828 to 1839, Babbage held the Lucasian Chair of Mathematics at Cambridge (a position he did not seek, once held by Sir Isaac Newton and currently by Stephen Hawkins). During his 12-year tenure, Babbage never gave a lecture or did any teaching of any kind. Despite having an abiding interest in pedagogical reform he had too many interests to find time to teach.

Babbage was drawn to the problem of the number of errors introduced into astronomical and other calculations through inaccuracies in the computation of tables. To deal with this, he spent much of his life in an attempt to build his two calculating machines. The "difference engine" was intended for the calculation of the lengthy tables needed for navigation and astronomy. It was called a *Difference Engine* because the mathematical principle on which it was based was the method of finite differences. It functioned by repeated addition performed by trains of gear wheels. In 1823 the government agreed to grant funds for the enterprise, but as Babbage kept coming up with new innovations so that the process that was supposed to take three years dragged on to ten, the government finally withdrew its financial support.

Babbage's better idea was the revolutionary *Analytical Engine*. If he had been successful in building it, his machine would have been the first general-use programmable computer. It would not be limited to solving one particular mathematical problem, but to perform a range of operations. Loops of punched cards were to control an automatic calculator, which could make decisions based on the results of the previous computations. The cards would be similar to the loops of Jacquard punched cards used in weaving with the Jacquard loom [Figure 10.9]. The Analytic Engine was designed to be driven by

steam and had it been built would have been the size of a locomotive with thousands of intermeshing clockwork parts. It was to have "a library of its own," in which 1000 numbers each of 50 digits were to be stored. The machine was meant to use several features subsequently found in modern computers, including sequential control, branching, and looping. Babbage never was able to build the Analytical Engine, not because the principal was wrong but because the project was too ambitious to be realized with the limited mechanical devices available at the time.

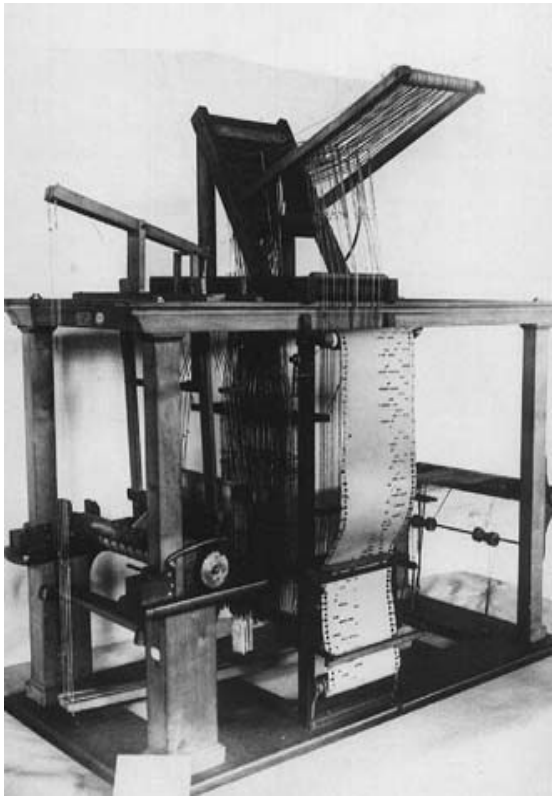

Figure 10.9

Babbage's unfinished version of the difference engine, and the drawings for the complete machine are located in the Museum at King's College in London and in the Science Museum, London. The assembled portion is about one-seventh of the complete engine. Babbage's major ally in the analytic engine project was Ada Byron, Lady Lovelace, the daughter of Lord Byron. She engaged in a life-long

correspondence with Babbage about the analytical engine. In 1843 she wrote an article that not only gave descriptive, analytical, contextual, but metaphysical information about the engine.

Babbage had an extraordinary range of achievements to his credit. He dabbled in cryptanalysis, probability, geophysics, astronomy, altimetry, ophthalmoscopy, statistical linguistics, meteorology, actuarial science, and the use of tree rings as historic climatic records. He compiled dictionaries for word-puzzlers, constructed a multipurpose surgical pump, and studied the transmission of light signals and submarine navigation on the diving bell. He pioneered lighthouse signaling, wrote a consumer guide to life assurance, proposed "black box" recorders for monitoring the conditions preceding railway catastrophes, developed mathematical code breaking, advocated decimal currency, highlighted the neglect of science and the status of scientists, and recommended the use of tidal power as a source of energy once coal reserves were exhausted. His other inventions included the cowcatcher for railroad engines, the dynamometer, an instrument for measuring the mechanical power of an engine, the standard railroad gauge, uniform postal rates, occulting lights for lighthouses, Greenwich time signals, and heliograph ophthalmoscope, an instrument used to examine the interior of the eye.

Babbage made significant contributions to political economy. In his *On the Economy of Machinery and Manufactures* (1832) he pioneered the field now known as *operations research*, the scientific analysis of business problems aimed at giving managers information that will allow them more effectively to run their businesses. Babbage offered a highly original discussion of the development of production technology. His views on the effect of the development of production technology on the size of factories were fundamental to Karl Marx's theory of capitalist socio-economic development. For 25 years, Babbage was a leading figure in London society, with hundreds of Europe's leading intelligencia gathering at his home to share ideas. He certainly earned his reputation as an eccentric. He nurtured an almost pathological hatred of organ grinders, which he wrote about with great seriousness in

"Observations of Street Nuisances" in 1864. He had a fascination with fire, once submitting to being baked in an oven at 265 degrees Fahrenheit for five or six minutes without any great discomfort. He looked into biblical miracles and calculated the chance of someone rising from the dead as one in 10^{12}. Wishing to quantify everything, he proposed to the Smithsonian Institution that an effort be made to produce "Tables of Constants of Nature and Art," to contain all the facts which could be expressed by numbers in the various sciences and arts. He offered some of the measures he had taken, including the heartbeat of a pig and the breath of a calf.

Babbage's autobiographical *Passages from the Life of a Philosopher* (1864) relates the crucial role of one of the key figures in the period in which Britain established itself as the most industrialized country in the world. In his autobiography, he wrote that in the creation of new tools he was guided by the principle that "inquiry should not be made whether that which is a defect as regards the object in view may not become a source of advantage in some totally different subject." Although a sociable and gregarious man who possessed a fine sense of humor, as he grew older the death of his father, his wife Georgiana Whitmore and two of his children combined with his frustration over his calculating machines turned him into a disappointed and embittered man. He died at his home on October 18. 1871.

As long as one is not the target of their abuse one can appreciate the eccentricities of great men. Someone remarked that Babbage was the mathematical Timon of his time, as he hated mankind in general, Englishmen in particular, and organ grinders most of all. In his obituary, the *Times of London* reported that he had lived to almost eighty "in spite of organ-grinding persecutions."

Quotation of the Day: "Errors using inadequate data are much less than those using no data at all. – Charles Babbage