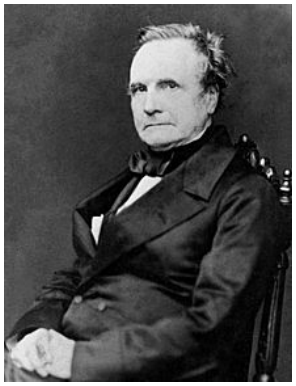
Charles Babbage

Born: December 26, 1791, in Teignmouth, Devonshire, UK- died 1871, London; known to some as the "Father of Computing" for his contributions to the basic design of the computer through his Analytical Engine. His previous Difference Engine was a special purpose device intended for the production of tables. While he did produce prototypes of portions of the Difference Engine, it was left to Georg and Edvard Schuetz to construct the first working devices to the same design, which were successful in limited applications.



Significant Events in His Life: 1791, born; 1810, entered Trinity College, Cambridge; 1814, graduated Peterhouse; 1817, received MA from Cambridge; 1820, founded the Analytical Society with Herschel and Peacock; 1823, started work on the Difference Engine through funding from the British Government; 1827, published a table of logarithms from 1 to 108000; 1828, appointed to the Lucasian Chair of Mathematics at Cambridge (never presented a lecture); 1831, founded the British Association for the Advancement of Science; 1832, published *Economy of Manufactures and Machinery*; 1833, began work on the Analytical Engine; 1834, founded the Statistical Society of London; 1864, published *Passages from the Life of a Philosopher*; 1871, died.

Other Inventions: The cowcatcher, dynamometer, standard railroad gauge, uniform postal rates, occulting lights for lighthouses, Greenwich time signals, heliograph ophthalmoscope. He also had an interest in cyphers and lock-picking, but abhorred street musicians.

Babbage Observed[1]

Near the northern pole of the moon there is a crater named for Charles Babbage. When he died in 1871, however, few people knew who he was. Only one carriage (the Duchess of Somerset's) followed in the burial procession that took his remains to Kensal Green Cemetery. The Royal Society printed no obituary, and the [London] Times ridiculed him. The parts of the Difference Engine that had seemed possible of completion in 1830 gathered dust in the Museum of King's College.

In 1878 the Cayley committee told the government not to bother constructing Babbage's Analytical Engine. By the 1880s Babbage was known primarily for his reform of mathematics at Cambridge. In 1899 the magazine *Temple Bar* reported that "the present generation appears to have forgotten Babbage and his calculating machine." In 1908, after being preserved for 37 years in alcohol, Babbage's brain was dissected by Sir Victor Horsley of the Royal Society. Horsley had to remind the society that Babbage had been a "very profound thinker."

Charles Babbage was born in Devonshire in 1791. Like John von Neumann, he was the son of a banker-Benjamin (Old Five Percent) Babbage. He attended Trinity College, Cambridge, receiving his MA in 1817. As the inventor of the first universal digital computer, he can indeed be considered a profound thinker. The use of Jacquard punch cards, of chains (sequences of instructions), and subassemblies, and ultimately the logical structure of the modern computer-all emanated from Babbage.

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[1] Reprinted with permission front Datamation, March 1985 (edited) ©1985 by Cahners/Ziff Publishing Associates, L.P.

Popularly, Babbage is a sort of Abner Doubleday of data processing, a colorful fellow whose portrait hangs in the anteroom but whose actual import is slight. He is thought about, if at all, as a funny sort of distracted character with a dirty collar. But Babbage was much more than that. He was an amazing intelligence.

The Philosopher

Babbage was an aesthete, but not a typical Victorian one. He found beauty in things: stamped buttons, stomach pumps, railways and tunnels, man's mastery over nature.

A social man, he was obliged to attend the theater. While others dozed at Mozart, Babbage grew restless. “Somewhat fatigued with the opera [Don Juan],” he writes in the autobiographical *Passages From the, Life of a Philosopher, “I* went behind the scenes to look at the mechanism.” There, a workman offered to show him around. Deserted when his Cicerone answered a cue, he met two actors dressed as “devils with long forked tails.” The devils were to convey Juan, via trapdoor and stage elevator, to hell.

In his box at the German Opera some time later (again not watching the stage), Babbage noticed “in the cloister scene at midnight” that his companion's white bonnet had a pink tint. He thought about “producing colored lights for theatrical representation.” In order to have something on which to shine his experimental lights, Babbage devised “Alethes and Iris,” a ballet in which sixty damsels in white were to dance. In the final scene, a series of dioramas were to represent Alethes' travels. One diorama would show animals “whose remains are contained in each successive layer of the earth. In the lower portions, symptoms of increasing heat show themselves until the centre is reached, which contains a liquid transparent sea, consisting of some fluid at white heat, which, however, is filled up with little infinitesimal eels, all of one sort, wriggling eternally.”

Two fire engines stood ready for the “experiment of the dance,” as Babbage termed the rehearsal. Dancers “danced and attitudinized” while he shone colored lights on them. But the theater manager feared fire, and the ballet was never publicly staged.

Babbage enjoyed fire. He once was baked in an oven at 265' for “five or six minutes without any great discomfort,” and on another occasion was lowered into Mt. Vesuvius to view molten lava. Did he ponder hell? He had considered becoming a cleric, but this was not an unusual choice for the affluent graduate with little interest in business or law. In 1837 he published his *Ninth Bridgewater Treatise,* to reconcile his scientific beliefs with Christian dogma. Babbage argued that miracles were not, as Hume wrote, violations of laws of nature, but could exist in a mechanistic world. As Babbage could program long series on his calculating machines, God could program similar irregularities in nature.

Babbage investigated biblical miracles. “In the course of his analysis,” wrote B.V. Bowden in *Faster than Thought* (Pitman, London, 1971), “he made the assumption that the chance of a man rising from the dead is one in 10^{12}.” Miracles are not, as he wrote in *Passages From the Life of a Philosopher,* “the breach of established laws, but ... indicate the existence of far higher laws.”

The Politician

Of all his roles, Babbage was least successful at this one. He had himself to blame: he was too impatient, too severe with criticism, too crotchety. Bowden wrote that in later life Babbage “was frequently and almost notoriously incoherent when he spoke in public.” What ultimately kept him from building an Analytical Engine was not his inability to finish a project, but his inadequacies as a political man, as a persuader. His vision was not matched by his judgment, patience, or sympathy.

Babbage was a confusing political figure. A liberal republican, he was pro-aristocratic and strongly antisocialist. Friend to Charles Dickens and to the workman, he was a crony to the Midlands industrialist. The son of a Tory banker, he supported the cooperative movement and was twice an unsuccessful Whig candidate to Parliament. But his liberalism waned during the 1840s; by 1865, he was a conservative utilitarian for whom capitalism and democracy were incompatible.

In July 1822, Babbage wrote a letter to the president of the Royal Society, describing his plan for calculating and printing mathematical tables by machine. By June 1823 Babbage met with the Chancellor of the Exchequer, who granted money and told Babbage to proceed with the engine (which he did, starting work in July). But no minutes were made of this initial meeting.

In August 1827, Babbage's 35 year-old wife, Georgiana, died. Babbage traveled to the Continent. By the end of 1828 he returned to England, the initial £1,500 grant gone. Babbage was financing the construction himself. And the exchequer could not recall promising further funds.

Convincing the government to continue with two tons of brass, hand-fitted steel, and pewter clockwork was not easy. In 1829 a group of Babbage's friends solicited the attention of the Duke of Wellington, and then the Prime Minister. Wellington went to see a model of the engine and in December ordered a grant of £3,000. Engineer Joseph Clement[1] was hired to construct the engine for the government, and to oversee the fabrication of special tools. By the end of 1830 Babbage wanted to move the engine's workshop to his house on Dorset Street. A fireproof shop was built where Babbage's stables had stood. A man of great ego, Clement refused to move from his own workshop, and made, according to Babbage, “inordinately extravagant demands.” Babbage would not advance Clement further money, so Clement dismissed his crew, and work on the Difference Engine ceased.

This did not seem to perturb Babbage. His initial scheme for the Difference Engine called for six decimal places and a second-order difference; now he began planning for 20 decimal places and a sixth-order difference. “His ambition to build immediately the largest Difference Engine that could ever be needed,” wrote Bowden, “probably delayed the exploitation of his own ideas for a century.”

With Clement and his tools gone, Babbage wanted to meet with Prime Minister Lord Melbourne in 1834 to tell him of a new machine he had conceived-the Analytical Engine, an improved device capable of any mathematical operation. He contended it would cost more to finish the original engine than to construct this new one. But the government did not wish to fund a new engine until the old one was complete. “He was ill judged enough,” wrote the Reverend Richard Sheepshanks, a secretary of the Royal Astronomical Society, “to press the consideration of this new machine upon the members of Government, who were already sick of the old one.” (Sheepshanks was Babbage's archenemy. In 1854 he published a vituperative 100-page work, “Letter to the Board of Visitors of the Greenwich Royal Observatory, in Reply to the Calumnies of Mr. Babbage,” at its meeting in June 1853, and in his book entitled *The Exposition of 1851*.)

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[1] See separate biography of Joseph Clement.

For the next eight years Babbage continued to apply to the government for a decision on whether to continue the suspended Difference Engine or begin the Analytical Engine, seemingly unaware of the social problems that preoccupied Britain's leaders during what Macauley called the Hungry Forties. Although £17,000 of public money had been spent, and a similar amount by Babbage, the Prime Minister avoided him. “It is nonsense,” wrote Sheepshanks, “to talk of consulting a Prime Minister about the kind of Calculating Machine that he wants.” Prime Minister Robert Peel recommended that Babbage's machine be set to calculate the time at which it would be of use. “ I would like a little previous consideration,” wrote Peel, “before I move in a thin house of country gentlemen a large vote for the creation of a wooden man to calculate tables from the formula x2+x+41.”

Finally, in November 1842, the Chancellor of the Exchequer, having sought the opinion of Sir George Airy on the utility of the machine, and having been told it was “worthless,” said he and Peel regretted the necessity of abandoning the project. On November 11, Babbage finally met with Peel and was told the bad news.

By 1851 Babbage had “given up all expectation of constructing the Analytic Engine,” even though he was to try once more with Disraeli the next year. He wrote in the vitriolic *Exposition of 1851:* “Thus bad names are coined by worse men to destroy honest people, as the madness of innocent dogs arises from the cry of insanity raised by their villainous pursuers.”

Some believed Babbage had “been rewarded for his time and labor by grants from the public use,” according to biographer Moseley Maboth *(Irascible Genius).* “We got *nothing* for our £17,000 but Mr. Babbage's grumblings,” wrote Sheepshanks in his “Letter to the Board of Visitors of the Greenwich Royal Observatory.” “We should at least have had a clever toy for our money.”

Peel, however, declared in Parliament that Babbage “had derived no emolument whatsoever from the government.” Offered a baronetcy in recognition of his work, Babbage refused, demanding a life peerage instead. It was never granted.

The Music Hater

Lady Lovelace wrote that Babbage hated music. He tolerated its more exquisite forms, but abhorred it as practiced on the street. “Those whose minds are entirely unoccupied,” he wrote with some seriousness in *Observations of Street Nuisances* in 1864, “receive [street music] with satisfaction, as filling up the vacuum of time.” He calculated that 25% of his working power had been destroyed by street nuisances, many of them intentional. Letters to the Times and the eventual enforcement of “Babbage's Act,” which would squelch street nuisances, made him the target of ridicule.

The public tormented him with an unending parade of fiddlers, Punch-and Judys, stilt-walkers, fanatic psalmists, and tub-thumpers. Some neighbors hired musicians to play outside his windows. Others willfully annoyed him with worn-out or damaged wind instruments. Placards were hung in local shops, abusing him. During one 80-day period Babbage counted 165 nuisances. One brass band played for five hours, with only a brief intermission. Another blew a penny tin whistle out his window toward Babbage's garden for a half hour daily, for “many months.”

When Babbage went out, children followed and cursed him. Adults followed, too, but at a distance. Over a hundred people once skulked behind him before he could find a constable to disperse them. Dead cats and other “offensive materials” were thrown at his house. Windows were broken. A man told him, “You deserve to have your house burnt up, and yourself in it, and I will do it for you, you old villain.” Even when he was on his deathbed, the organ-grinders ground away implacably.

In Babbage's relation with “the Mob,” we see his curious naïveté in matters social. Although he was far above the rabble-”not unknown” to the Duke of Wellington and Lord Ashley-he seemed unaware of it at times. He expected the same civility from a drunken brothel-keeper as he would from a gentleman. In 1860, the London of the multitudinous poor was far from gentle. Yet, in his ingenuousness, he could fathom neither bums nor bamboozlers. He would cross town to check the tale of a mendicant, and frequently was surprised to encounter deceit.

Babbage once met a man who claimed not to have eaten for two days. Babbage invited him to breakfast. The next morning he called at Babbage's house, claiming hard times. Eventually, the man hired on as a steward on a small West Indian ship. “A few evenings after the ship had supposed to have sailed, he called at my house,” wrote Babbage, “apparently much agitated and stated that, in raising the anchor, an accident had happened, by which the captain's leg had been broken.” Babbage later tried to verify this tale, but found his steward “had been living riotously at some public-house in another quarter, and had been continually drunk.”

Babbage never understood that the growth and crowdedness of London resulted from the industrial expansion he championed. By 1850 industry had taken over in Britain. “Many years before, I had purchased a house in a very quiet locality,” he wrote in 1864. Then came a hackney stand, and beer shops and coffeehouses, and people. The din beneath his window, the German bands, the pickpockets, came with industry. The railroad and factory brought crowds to London, and with them came meanness and thievery.

The Newtonian

Like Newton, Babbage was Lucasian professor of mathematics at Cambridge. He founded both the British Association's Statistical Society and the Royal Astronomical Society. His Difference Engine calculated by Newton's method of successive differences, and would even accomplish “operations of human intellect” by motive power. Babbage believed in a world where, once all things were dutifully quantified, all things could be predicted. As such, he was a perfect Newtonian.

Nature, according to Question 31 of Newton's Opticks, is “very consonant and conformable to herself.” Newton's program was official in Babbage's time. Science “consisted in isolating some central, specific act, and then using it as the basis for all further deductions concerning a given set of phenomena,” writes Ilya Prigogine in *Order Out of Chaos*. The Marquis Laplace, an avid Newtonian and friend of Babbage, said that if a mind could know everything about particle behavior, it could describe everything: “Nothing would be uncertain, and the future, as the past, could be present to our eyes.”

Babbage wanted to quantify everything. Fact and data intoxicated him. He tried handicapping horse races mathematically. Babbage's love of numbers was well known: in the mail he received requests for statistics. He would preserve any fact, simply because he thought “the preservation of any fact might ultimately be useful.”

He would stop to measure the heartbeat of a pig (to be listed in his “Table of Constants of the Class Mammalia”), or to affix a numerical value to the breath of a calf. In 1856 he proposed to the Smithsonian Institution that an effort be made to produce “Tables of Constants of Nature and Art,” which would “contain all those facts which can be expressed by numbers in the various sciences and arts.”

Babbage delighted in the thought of having a daily account of food consumed by zoo animals, or the “proportion of sexes amongst our poultry.” He proposed tables to calibrate the amount of wood (elm or oak) a man would saw in ten hours, or how much an ox or camel could plow or mow in a day.

Babbage's unflagging fascination with statistics occasionally overwhelmed him, as is seen in the animation of his Smithsonian proposal. “If I should be successful,” he wrote, “. . . it will thus call into action a permanent cause of advancement toward truth, continually leading to the more accurate determination of established fact, and to the discovery and measurement of new ones.”

In *Mechanics Magazine* in 1857 Babbage published a “Table of the Relative Frequency of the Causes of Breaking of Plate Glass Windows,” detailing 464 breakages, of which “drunken men, women, or boys” were responsible for fourteen. Babbage thought the table would be “of value in many respects,” and might “induce others to furnish more extensive collections of similar and related facts.”

Babbage faced significant problems with mechanical techniques. He had to invent the tools for his engine. His thought is so thoroughly modern that we wonder why he did not pursue electromechanical methods for his engines (especially after Faraday's 1831 discovery of induction and Babbage's own electrical experiments). It is easy to forget how long ago Babbage worked.

Even under the best of circumstances, the limitations of Newtonian physics might have prevented Babbage from completing any Analytical Engine. He did not know the advances of Maxwell (and could not know those of Boltmann, Gödel, and Heisenberg). Although he knew Fourier socially, Babbage did not seem to grasp the importance of his 1811 work on heat propagation, nor did he seem to know of Joule's efforts with heat and mechanical energy.

The reversibility of attraction is a basic tenet of Newtonian mechanics. A body, or piece of information, may retrace its path and return to where it started. In Babbage's design for the Analytical Engine, the discrete functions of mill (in which “all operations are performed”) and store (in which all numbers are originally placed, and, once computed, are returned) rely on this supposition of reversibility.

In his 1824 essay on heat, Carnot formulated the first quantitative expression of irreversibility, by showing that a heat engine cannot convert all supplied heat energy into mechanical energy. Part of it is converted to useful work, but most is expelled into a low-temperature reservoir and wasted.

From this observation came William Thomson's discovery of the Second Law of Thermodynamics in 1852, and Rudolf Clausius' discovery of entropy in 1865. In ideal reversible processes, entropy remains constant. But in others, as Eddington showed with his “arrow of time,” entropy only increases; thus, information cannot be shuttled between mill and store without leaking (some possibility of error), like faulty sacks of flour. Babbage did not consider this problem, and it was perhaps his greatest obstacle to building the engine.

It is easy to forget that Babbage was essentially a child of the Enlightenment, and that his epoch was much different from our own. He resided in an era of wood and coal, and the later era of steel and oil would not begin for perhaps a decade after his death.

The Industrialist

“Faith in machinery,” wrote Matthew Arnold in *Culture and Anarchy* in 1869, “is our besetting danger.” The Whiggery of the mid-Victorian era optimistically endorsed the principle of progress. Britain changed from the relatively pastoral society of 1820 to the brutishly materialistic one of the 1840s and 1850s.

Babbage shared his era's enthusiasm for industry. His finest work, *On the Economy of Manufactures,* was published in 1832. In it, with watch in hand, Babbage discovers operational research, the scientific study of manufacturing processes. It is a tour of the manufacturing processes of the period, from needle-making to tanning. Babbage detailed how things both ornamental and functional were made in mid-nineteenth century Britain. His characteristically blunt analysis of the printing trade caused publishers to refuse his books.

Babbage worked when industry was in a frenzy to improve and expand. Increases in manufacturing and population were viewed as “absolute goods in themselves,” noted Matthew Arnold. In *Das Kapital,* Marx quoted from *Economy of Manufactures* on this rage to improve: “Improvements succeeded each other so rapidly, that machines which had never been finished were abandoned in the hands of their makers, because new improvements had superseded their utility.”

Babbage disliked Plato, according to his friend Wilmot Buxton, because of Plato's condemnation of Archytas, “who had constructed machines of extraordinary power on mathematical principles.” Plato thought such an application of geometry degraded a noble intellectual exercise, “reducing it to the low level of a craft fit only for mechanics and artisans.”

Babbage loved practical science, and was among the first to apply higher mathematics to certain commercial and industrial problems. He took no part in what Anthony Hyman (in his book, *Charles Babbage)* called the era's “growing divorce between academic science and engineering practice.”

Babbage had a forge built in his house on Devonshire Street, and accomplished, with his draftsmen, pioneering work in precision engineering. Because conventional mechanical drawing proved inadequate for his engines, he had to develop his own abstract notation. He called his work with mechanical notation “one of the most important additions I have made to human knowledge.”

With the die-cast pewter gear wheels of his Difference Engine, and with his design of lathes and tool-shapers, Babbage did much to advance the British machine tool industry. Joseph Whitworth (later Sir), foreman in Babbage's shop, was responsible for the introduction of the first series of standard screw threads.

The expansion of the railways marked the grandest phase of the industrial revolution. Railroads freed manufacturing from its dependence on water transport, and opened new markets. When the first public railroad, the Stockton & Darlington, opened on September 27, 1823, Babbage was 34. By 1841 there were over 1,300 miles of rail in Britain, and 13,500 miles by 1870. J.D. Bernal wrote in *Science and Industry in the Nineteenth Century*, that “Babbage seems to have been one of the few who interested themselves scientifically in its [the railroad's] working.” Babbage's life was intertwined with the railroad. He invented a cow catcher in 1838, apparently the first in Britain. He was present for opening ceremonies of George Stephenson's Manchester & Liverpool line in 1830. Of the cheering crowds at the initial run, he wrote, “I feared . . . the people madly attempting to stop by their feeble arms the momentum of our enormous train.”

Babbage's great formal association with railroads came in 1837 and 1838, when he conducted experiments for I.K. Brunel's Great Western Railway, which ran from London to Bristol. Babbage argued for the superiority of

Brunel's wide-gauge track. His research into the safety and efficiency of the line was, according to Bernal, “100 years ahead of his time.”

Babbage rode the rails like a river pilot road the Mississippi, knowing every turn on the route, every crossing, every intersection. “My ear,” he wrote, “had become peculiarly sensitive to the distant sound of an engine.”

The Misanthrope

Babbage was known as a “mathematical Timon.” In his later years he came to suffer from a mechanist's misanthropy, regarding men as fools and grubby thieves. By 1861 he said he had never spent a happy day in his life, and would gladly give up the rest of it if he could live three days 500 years thence.

Laughed at by costermongers and viscounts, met with diffidence by his lessers, the impatient Babbage grew angry, like the cave-dwelling Timon, with a changing world. Nevertheless, as his friend Lionel Tollemache wrote, “there was something harmless and even kindly in his misanthropy, for ... he hated mankind rather than man, and his aversion was lost in its own generality.”

Like Shakespeare's Timon, Babbage would have made a fascinating leader. (Sheepshanks, of course, disagreed: “I don't know any Government office or any other office for which he is fit, certainly none which requires sense and good temper.”)

What a delightful, if distracting, place it would be where Babbage was in charge. Consider his plan in *Economy of Manufactures* for a “simple contrivance of tin tubes for speaking through.” (Babbage calculated it would take 17 minutes for words spoken in London to reach Liverpool.) Or his plan for sending messages “enclosed in small cylinders,” along wires suspended from high pillars (he thought church steeples could be used for this purpose.)

In *Passages*, Babbage relates how, as a youth, he nearly drowned while testing his contrivance for walking on water. In *Conjectures on the Conditions of the Surface of the Moon*, we find him describing his 1837 experiments in cooking a “very respectable stew of meat and vegetables” in blackened boxes (with window glass) buried in the earth. Toward the end of his life we find him mulling the prevention of bank note forgery and working in marine navigation. We realize that, with his harlequin curiosity about all things, and with his wonderfully human sense of wonder, Babbage escapes pathos and attains greatness.

QUOTATIONS

“Some of my critics have amused their readers with the wildness of the schemes I have occasionally thrown out; and I myself have sometimes smiled along with them. Perhaps it were wiser for present reputation to offer nothing but profoundly meditated plans, but I do not think knowledge will be most advanced by that course; such sparks may kindle the energies of other minds more favorably circumstanced for pursuing the enquiries.” *(On the Economy of Machinery and Manufactures*, 1832, preface to second edition)

“Every moment dies a man/Every moment 1 $^{1}/_{16}$ is born.' (A correction to Tennyson's “Every moment a man dies/Every moment one is born.”)

"If unwarned by my example, any man shall undertake and shall succeed in really constructing an engine ... upon difference principles or by simpler means, I have no fear of leaving my reputation in his charge, for he alone will be fully able to appreciate the nature of my efforts and the value of their results."[1]

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[1] Quoted in the Babbage exhibit at the Science Museum, Kensington; attributed to Babbage in 1864.

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Babbage, Charles, *Economy of Machinery and Manufactures*, Charles Knight, London, 1832.

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[1] Also in 3ed edition.

Babbage, Charles, “On the Mathematical Powers of the Calculating Engine, unpublished MS, reprinted in Randell, B., ed., *The Origins of Digital Computers: Selected Papers*, Springer-Verlag, Berlin, 1973, pp. 19-54.

Babbage, Charles, *Passages from the Life of a Philosopher*, Longmans and Green, London, 1864, reprinted with introduction by Martin Campbell-Kelly, IEEE Press, Piscataway, NJ., 1994.

UPDATES

(Babbage portrait inserted by MRW, 2012)