Babbage's Engines

Though we think of the computer as a distinctly 20th century invention, Charles Babbage designed several precursors way back in the early 1800s.

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Today, we use electronic mathematical tables for everything from astronomy to finance. But when Charles Babbage was born all the way back in 1791, these tables were all done by hand, and that meant they were susceptible to human error. Babbage spent a portion of his early life double-checking these tables, and was often frustrated by just how many he found.

That frustration drove Babbage to invent the Difference Engine, a behemoth machine designed to calculate polynomial tables, in 1821. The machine could only use addition, but could still calculate tables utilizing the method of differences. The Difference Engine was run with a simple hand crank, with the idea being to literally plug and chug the numbers. It was essentially a room-sized calculator, but a thirst for the infallible calculating power of exacting machinery inspired the government to fund the machine's construction.

Just designing the Difference Engine was no small feat of genius, but Babbage found that actually building the machine was an even more difficult proposition. The design called for a staggering 25,000 parts, including numerous gearwheels, and each needed to be cut to exacting specifications. Even after £17,500 of funding from the British government and 12 years of work, all Babbage had to show for his effort was a prototype for a single section of the machine. While the prototype drew plenty of attention, patience and funding eventually ran out, and the Difference Engine was never completed.

But Babbage had already moved on to a new project: The Analytical Engine. Unlike the Difference Engine, this newest design has been hailed as a full-on precursor to the modern computer due to the way it pioneered many design concepts that are still used for computers today. It was structured in two parts, with one being a "store" where much of the setup or intermediate solutions could be temporarily kept and results could be printed, the other a "mill" where the actual number crunching happened. The design mirrors how computers work today, with memory storage and a processor separate from each other.

The Analytical Engine also utilized a punch card system to program its calculations. Babbage borrowed the idea for the punch card system from the Jacquard loom. The idea would, in turn, later become a necessary part of early modern computer systems. It was also capable of a much wider range of calculations than the Difference Engine, now able to subtract, multiply and divide.

Much like with the Difference Engine, Babbage moved on to new ideas before the Analytical Engine was ever built, this time redesigning his original project. The Difference Engine No. 2 required only 8,000 parts, a fraction of what the original called for, and could calculate polynomials up to the seventh order. The machine also took Babbage's earlier idea for a separate printer and added it to the Difference Engine.

Ultimately, however, the Difference Engine No. 2 met the same fate as Babbage's earlier inventions. Either because of the complexity of the machines or his unyielding personality and dedication to perfection, Babbage never finished any of his machines before moving on to his next idea. To this day, only one full Difference Engine based on the 2.0 model has ever been completed, and work on it didn't even start until 1985, well after it had been obsoleted by computers.

The Science Museum in London set out to build a Difference Engine No. 2 by following Babbage's design both to prove that it had been a technologically feasible machine and to honor the 200th anniversary of Babbage's birth.

Just one of the countless gearwheels used to make Babbage's engines function. Photo by Marcin Wichary, originally posted to flickr.com (licensed under CC BY 2.0).

But even with modern manufacturing techniques, recreating Babbage's Difference Engine No. 2 was a 17-year effort fraught with technical and financial challenges. While the calculating half of the machine was completed in 1991 just in time for the anniversary, the rest wouldn't be completed until 2002. But eventually, the team managed to put it together without deviating from Babbage's design, and the Difference Engine is still on display at the Science Museum in London today.

Several other artifacts of Babbage's work are on display elsewhere in the world. The Smithsonian displays a single segment of the full machine that was made in 1853, and there's a replica that was created for a Microsoft executive, but the only original, full Difference Engine to ever be completed resides in London.