Why do we call it a...Watt?

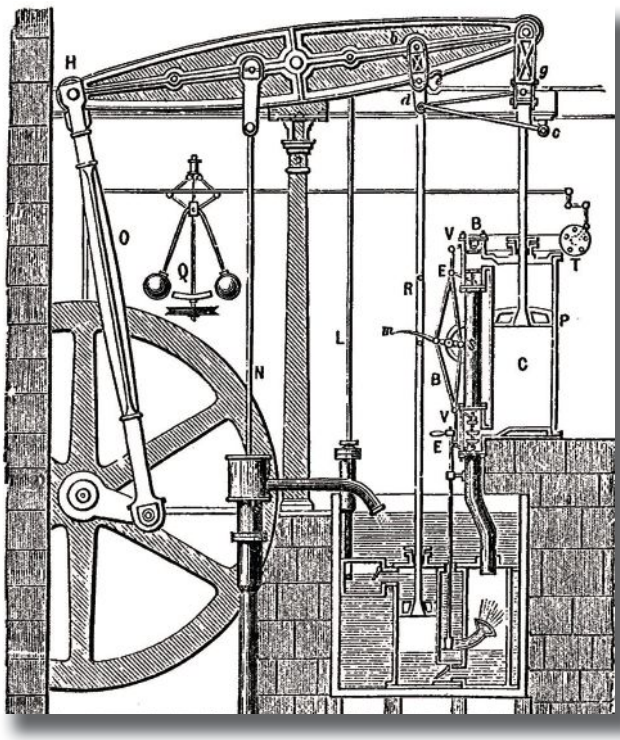
by Lyle D. Feisel, Ph.D., P.E. (Ret.), *Iowa Alpha '61*

First we wrote about Volta. Then we wrote about Ampère. What's next? Well, make that question into an affirmative statement and you have your answer. Watt's next.

Volts, which are the units in which electric potential is measured, are interesting, but we know that nothing useful happens until we also have some current, measured in amperes. When we have a voltage *and* a current, energy is converted from one form to another; from mechanical to electrical, say, or electrical to thermal. As we all know, the *rate* at which that energy is converted is measured in watts, one watt being equal to one joule per second.

The namesake of the watt is James Watt who was born in Scotland in 1736 and died in 1819. While most people for whom physical units are named would be considered scientists, Watt was first and foremost an engineer and craftsman, and also an entrepreneur. It's not that he didn't understand the science of the day, which was still in its infancy. That was important to him, but he appears to have been motivated primarily by the goal of making machines that did something useful and also —not incidentally—would generate some income. Sounds like an engineer.

This is the third in a series of articles that explore the history of science and engineering. One way in which this history has been preserved is in the names of the scientific units that we commonly use. Those units will serve as starting points for these articles as we explore "Why do we call it a…?"



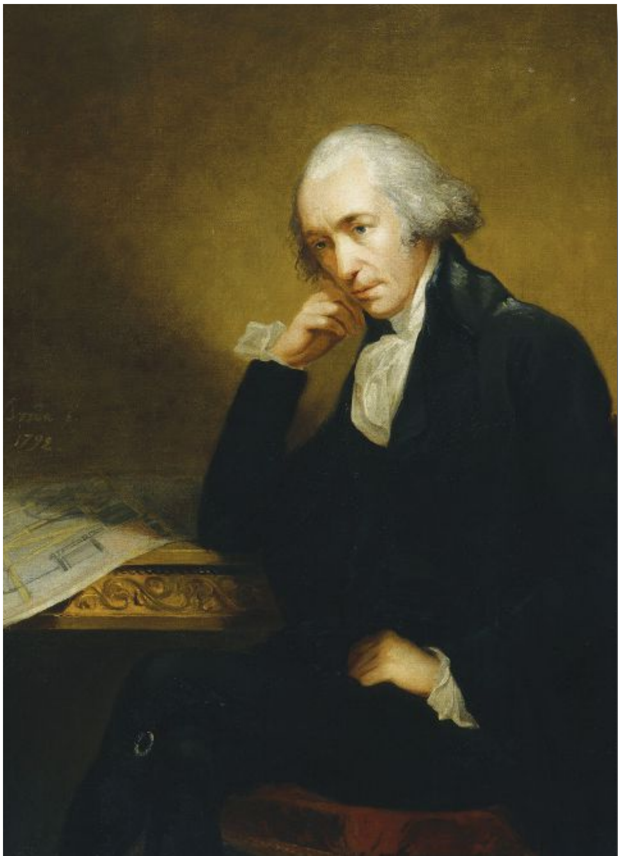
Boulton and Watt steam engine of 1784. The Watt external condenser is at the bottom, right, shown with a spray of water.

Watt's family was what we would probably call upper middle class today. His father was a ship builder and his mother was well educated, not too common for a woman in the 18th century. His first few years of schooling were provided by his mother at home but he was later enrolled in a formal school. At the age of 18, he began studying the practice of instrument making. This was a time when there was great interest in science by both scholars and amateur scientists. Hence there was considerable demand for various precision instruments ranging from accurate scales to astronomical telescopes to mechanical calculators. These scientists couldn't simply pick up a catalog (or go to the Internet) to find what they wanted; rather, they would visit an instrument maker like Watt and either find what they needed or work with the craftsman to have it built. But we don't remember Watt for his instrument making.

Power was Limited

To appreciate Watt's contribution to our history, we have to go back to the early 1700s. At that time, Britain—and indeed much of Europe—was shifting from charcoal to coal as a fuel for cooking, heating and fueling industrial processes such as smelting. That coal, along with the ores that fed those processes, was generally produced from underground mines, which, since they were below the water table, collected water. To keep the mines dry—or at least dry enough for miners to work—this water had to be removed using pumps powered by humans, horses, waterwheels or windmills. But the power available from those sources is limited and consequently, so was the depth at which mines could be profitable.

In 1712, this limitation was alleviated when Thomas Newcomen invented the first workable steam engine. In the Newcomen engine, a piston in a vertical cylinder was connected to one end of a pivoted beam and a pump rod to the other. When steam was introduced into the cylinder, it pushed the piston up and allowed the pump



A portrait of James Watt painted by Carl Fredrick von Breda around 1792.

rod to go down. Once the cylinder was full of steam, the inlet valve was closed and cold water was sprayed into the cylinder, causing the steam to condense and form a partial vacuum. Atmospheric pressure on the top of the piston then pushed the piston down, causing the pump rod to come up, bringing with it a load of water. The process was then repeated and the water was pumped from the mine.

The Newcomen engine, however, had a major flaw. When steam was introduced into the cylinder, a significant fraction of its energy was used to heat the walls of the cylinder which were then cooled by the spray of cold water. This energy produced no useful work. And here is where our hero, James Watt, enters the story. Around 1775—at the time of the American revolution and some 60 years after introduction of the Newcomen engine—Watt recognized that the steam could be let into another chamber, an external condenser, where the walls could be kept cold while the walls of the cylinder remained hot. This resulted in a significant increase in efficiency (from perhaps 0.05 % to 0.5%) and thus was born the Watt steam engine for which James Watt is famous.

Reciprocating steam engines are rarely used today, but steam turbines perform the same function of converting thermal energy into mechanical energy. And to be efficient, the turbines need to exhaust into an external condenser, just like in Watt's engine of 200 years ago. The huge cooling towers seen near thermal power plants cool the water that in turn cools the condenser.

James Watt is also noted for another achievement closely related to the naming of the unit of power in his honor. As he designed and built ever larger and more efficient steam engines, he recognized that he needed some way to compare their outputs to each other and to the other sources of energy that his engines were replacing. I can imagine—without any historical justification whatsoever—that he considered defining the personpower but decided that was too small to be convenient. So he defined horsepower instead. He determined experimentally that if a typical horse was hoisting a load at a reasonable rate, that horse could lift a load of 550 pounds at a speed of one foot per second. He called this, quite logically, one horsepower.

A horsepower is roughly equal to 746 joules per second, i.e., 746 watts. But we still use horsepower to rate engines. My car is purported to have a 268 horsepower engine. Fortuitously, that equates to a nice round 200 kilowatts but that figure isn't used by the manufacturer.

Precision Machining

In this age of computers, 3D printing, and precision machining, it is hard to imagine how difficult it was to build these steam engines some 250 years ago. For one thing, they were huge; cylinders were several feet in diameter and the piston stroke could be six to ten feet. There were no machines for boring cylinders of that size, so they were often fabricated from sheet metal and ground and hammered until they were reasonably circular. Leather seals helped to reduce leakage. It is no wonder these early steam engines had such low efficiencies.

Watt and his partner, Matthew Boulton, continued to improve their steam engines and to sell them broadly to the mining industry. They also developed the machinery to convert the linear motion of a piston to the rotary motion that was useful in driving many of the machines involved in the Industrial Revolution. Watt didn't invent the first steam engine but he made it practical. And he defined the horsepower, which is a unit of power, just like the watt. And that is why we call a watt a watt.

Want to know more about our history? Check out the Engineering Technology and History Wiki: *http://ethw.org/*.

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