ESSAYS ON SCIENCE AND SOCIETY

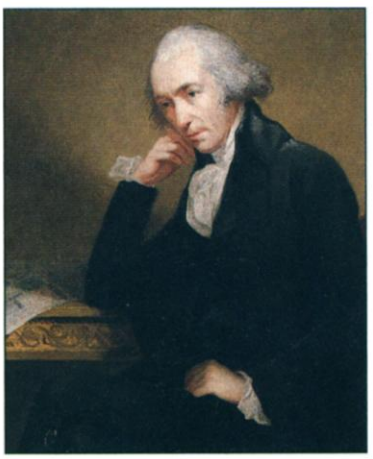
James Watt and the Lunaticks of Birmingham

Adam Hart-Davis

trained as a chemist, but is best known in Britain as the presenter of a BBC television series called *Local Heroes*, in which he cycled around telling the stories of pioneers of science and technology, showing where they lived or worked, and what they did, using low-tech demonstrations, from riding an atmospheric railway to dropping tomatoes off the leaning tower of Pisa. More recently he has made series on Roman and Victorian technology.

For 24 years I have been putting science on television, first as a researcher, then as a producer, and most recently as a presenter. Most of my programs today are about the history of technology and science. Making programs about long-dead pioneers is great fun, partly because I can say what I like about them without fear of getting sued, and partly because their science was simple.

Several of my favorite "heroes" belonged to a group of intellectuals in the English Midlands who, around 1765, began to come together regularly to discuss what they called natural philosophy—everything from the latest design of steam engines to the new gases that were being discovered by Priestley, Lavoisier, and others. They would meet for dinner and argue on into the night before climbing on their horses to ride home. And because they wanted to be able to see their way, they chose to meet each month on the Sunday nearest to the full moon—which was why they called themselves the Lunar Society of Birmingham, or the Lunaticks.



James Watt

The meetings were started by Erasmus Darwin, Matthew Boulton, and William Small. Erasmus was an enormously fat, popular, and successful doctor, a prolific inventor, father of 12 children by his two wives and two more by a governess, and grandfather of the famous Charles Darwin. Boulton was a manufacturer of buckles and a bold entrepreneur. Small was Boulton's doctor and had been teacher and mentor of the great American politician Thomas Jefferson. They were later joined by Charles Darwin's other grandfather, the potter Josiah Wedgwood, chemist James Keir, steam-engine builder James Watt, chemist Joseph Priestley, and several others. In all, there were some 14 members, though not all at the same time. The meetings were held almost every month for more than 30 years. Arguably, there has never before or since been such a regular concentration of scientific intellect meeting under one roof.

In the early years, Darwin held the dinners at his fine house (now restored and open to the public) within a stone's throw of the cathedral in Lichfield. Later Boulton took over as host, inviting the group to his new home, Soho House in Birmingham, which he called "*l'hôtel d'amitié sur Handsworth Heath.*" Soho House too has been restored to something like its fine original state; it boasted special metal alloy window frames, hot-air central heating—you can still see the grills in the stair rises where some of the air escaped—and a newfangled Bramah water closet!

The most famous Lunatick, James Watt, is frequently but wrongly credited with the invention of the steam engine. Actually, the first steam-engine patent was granted in 1698, the year James Watt's father was born. By the time James was born in 1736, at Greenock on the River Clyde, Newcomen engines had been pumping water out of the coal mines in the Midlands for some 24 years.

Each Newcomen engine was a monster, with a large boiler feeding steam straight up into a cast-iron cylinder, often 6 feet in diameter and 10 feet high. As the cylinder filled with steam, the piston rose, allowing the beam above to rock upwards. Hanging from the other end of the great beam, iron pump rods descended into the mine. When the cylinder was full, the supply of steam was shut off and cold water squirted in to condense the steam inside. This created a partial vacuum, and the pressure of the atmosphere on the top of the piston pushed it down, pulling the beam down after it, lifting the pump rods, and so pumping water from the mine. These massive engines ran at perhaps five or six strokes a minute, slow but inexorable.

James Watt first became interested in the Newcomen engine late in 1764, when someone brought him a model that had been repaired but would not run, and asked whether he could fix it.

James Watt's brothers and sisters all died in infancy, and his mother no doubt coddled and spoiled him, for he became a terrible hypochondriac, convinced he was about to die throughout his 83 years. A contemporary writer, Mary Ann Galton, wrote that he "was one of the most complete specimens of the melancholy temperament. His head was generally bent forward or leaning on his hand in meditation; his shoulders stooping, and his chest fallen in." Nor did he show early promise of becoming a genius. He was apprenticed to an instrument maker in London, returned to Glasgow, set up a small business, and got a job as instrument repairer at the university.

Watt realized that the problem with the model Newcomen engine was that it was hopelessly inefficient; masses of coal had to be burned to generate enough steam for just a couple of strokes. But he could not understand why.

To solve the problem completely, he needed one stroke of inspiration and three slices of luck. His first slice of luck was to talk about the problem to his friend and mentor Joseph Black, a brilliant chemist 8 years his senior. Black had spent some years teaching at Edinburgh University, where many of his

A. Hart-Davis, 31 Berkely Road, Bishopston, Bristol, BS7 8HF, UK.

students were the sons of whisky distillers. They had come to him for advice about running their distilleries; why did they have to spend so much money distilling the liquor, and then even more condensing the vapor?

Put a saucepan of water on the stove, turn up the heat, and the temperature of the water goes up. But when it starts boiling, the temperature stops rising. However high you turn the heat, the temperature sticks stubbornly at 100°C. Black realized that the heat is needed simply to turn the liquid into vapor at the same temperature; we would now say the heat gives the water molecules enough extra kinetic energy to escape from the surface of the liquid. Because this heat appears to be lost, Black called it "latent heat," meaning hidden heat. This latent heat was what was costing the distillers so much money—and it was also the source of Watt's problem.

Erasmus Darwin

Each time he put steam into the cylinder of his Newcomen engine he had to raise the temperature of the whole cylinder above 100°C, which used up a lot of steam, and then he had to cool it down again to make the steam condense. Having talked it over with Black, Watt came up with a simple solution: keep the cylinder hot, and condense the steam somewhere else. The idea of using a separate condenser hit him one Sunday afternoon in May 1765, while he was walking on Glasgow Green. According to Sam Smiles, Watt later said, "I had not walked further than the Golf-house when the whole thing was arranged in my mind."

This inspiration came to Watt some 6 months after he first started thinking about the problem, but another 10 years went by before he actually got a steam engine to work. He probably built the first prototype in a tiny cottage behind the grand house of his financial backer, John Roebuck, at Bo'ness, northwest of Edinburgh, but he could not get a steam-tight fit between the piston and the cylinder. Both were made of cast iron, and the technology was not good enough to make the cylinder accurately parallel-sided.

In 1769, Watt took out a patent for his steam engine, and on his way to and from London stopped in Birmingham to meet Small, Darwin, and later Boulton, who did their best to persuade Watt to come south and join them. Five years later, after his wife died and John Roebuck went bankrupt, Watt did indeed move to Birmingham and formed a partnership with Matthew Boulton, who had no doubts that Watt was a genius needing only time and facilities to be successful.

This was Watt's second slice of luck. Boulton provided him with money and a splendid array of craftsmen in his Soho Manufactory. He also kept Watt focused on the steam engine and restrained him from going off in pursuit of other goals.

Watt's third lucky break came in the shape of the new boring machine invented by ironmaster John "Iron-mad" Wilkinson. Wilkinson was a splendid, larger-than-life character who wanted to make everything from iron. He built a chapel at Wolverhampton with iron window frames, an iron pulpit (now painted to look like wood), and iron pews, which must have been uncomfortable in winter. He built an iron boat that everyone wrongly said would sink; he was involved in the construction of the famous iron bridge over the Severn, at what is now Ironbridge; and in the corner of his office he kept his own iron coffin, which he proudly showed off to visitors. (This caused some trouble when he died, for his wooden coffin turned out to be too big to fit in the iron one; so they had to bury him temporarily in the garden while they cast another iron coffin. Then they dug him up, put his wooden coffin in the new iron one, and found it would not fit in the hole in the rock. So again they buried him temporarily, blasted a bigger hole, dug him up, successfully buried him, and placed a large iron obelisk on the grave. Unfortunately, the house changed hands a few years later, and the new owners did not like this great 20-ton iron pillar in front of their sitting-room window; so poor Iron-mad was dug up yet again and buried for the fourth time at Lindale in the Lake District.)

In 1775, Wilkinson built his new boring machine to make better cannons. Before then, he had made them by casting, but this never produced a perfectly cylindrical barrel, and the ball had to fight its way out past numerous lumps and bumps. By casting the barrel solid, and boring a smooth cylindrical hole, Wilkinson hoped to make a more powerful and accurate cannon. Watt heard about this, and asked Wilkinson whether he could make a cylinder for a steam engine. Within weeks of getting this new cylinder, James Watt got his first steam engine to work. The second steam engine he made went to drive the blowers for Wilkinson's furnace, and for 20 years Wilkinson made the cylinders for the Boulton & Watt steam engines.

James Watt is world-famous for his steam engine; yet, not only did it take him 10 years to get one to run at all, and a further 10 before he made any money from it, but he could not have succeeded without the help of Joseph Black, Matthew Boulton, and John Wilkinson.

The Lunar Society believed in argument and cooperation. They had long discussions about why thunder rumbles and decided the best way to test their various theories was by experiment. Boulton made a 5-foot-diameter balloon from varnished paper, and they filled it with a terrifying mixture of air and hydrogen ("inflammable air from iron"). They lit a fuse underneath, released the balloon into the night sky on a calm, clear evening and waited for the bang. Unfortunately, the fuse was rather long, and they all assumed it must have gone out; so they began to talk among themselves, when there was a colossal explosion, and they all said, "There it goes!" and forgot to listen for the rumble! Watt was at home 3 miles away and wrote that the bang was "instantaneous, and lasted about one second." This seems self-contradictory, but in any case, the experiment failed to produce a simple answer to the original question.

" 'Lord, what invention, what wit, what rhetoric...' "

There are further tales to be told about Watt's copying machine and his "parallel motion," about Darwin's speaking machine, and the horizontal windmill he designed for Wedgwood. However, perhaps the whole ethos of the Lunaticks can be summed up by a quote from a letter Darwin wrote to Boulton, apologizing for having to miss a meeting: "Lord, what invention, what wit, what rhetoric, metaphysical, mechanical, and pyrotechnical, will be on the wing, bandied like a shuttlecock from one to another of your troup of philosophers."

The story of the Lunaticks shows that science and technology advance through intellectual exchange between people from all walks of life. Unfortunately, many television producers believe that science is frightening and incomprehensible and go to any lengths to protect the poor innocent public from its elegant ideas. But almost any science story can be told to a wide audience without desperate hype or sugaring of the pill. There is not necessarily one correct way to present science and technology to the public, but let us have the courage to explain in simple language the hard work, the inspiration, the disappointments, and the frustrations of trying to uncover nature's secrets and to share the excitement and exhilaration of scientific discovery. I would like everyone to find science as entertaining as the Lunaticks did.

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