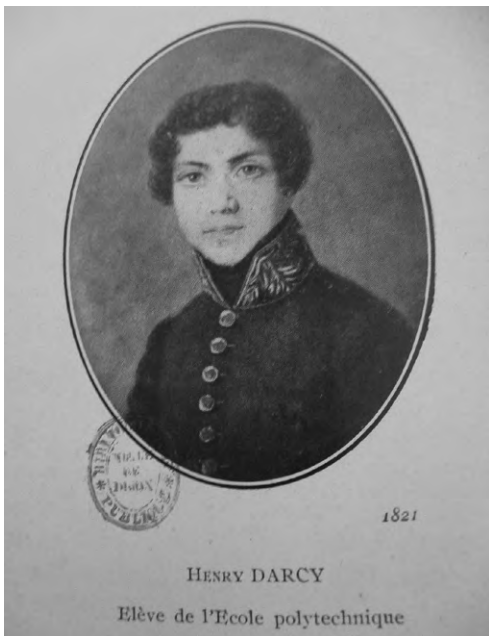


Henry Darcy (1803–1858): Founder of Quantitative Hydrogeology

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Henry Darcy, age 18. Student at Ecole Polytechnique, 1821. Courtesy: Bibliothèque municipale de Dijon.

INTRODUCTION: DARCY AND THE SOCIO-POLITICAL BACKGROUND OF 19TH CENTURY FRANCE

Henry Philibert Gaspard Darcy was born in Dijon, France, on 10 June 1803, during Napoleon's rise to power after the French Revolution. Napoleon's support for engineering and opportunity for talented youth made Darcy's career possible. Napoleon's educational reforms survived the Bourbon (deposed king's family) restoration from 1815 to 1830; Darcy completed his studies during these years. The 1830 revolution brought Louis Philippe, a member of the Orleans branch of the Bourbons, to power in a constitutional monarchy (1830–1848). During this period, Darcy proposed, planned, and built the Dijon water system. Between 1848 and 1858, Darcy was ousted from Dijon, was promoted to the highest rank of the engineering corps, worked in England and Belgium, conducted research on pipes and filtration, and published Darcy's Law.

DARCY'S YOUTH

Henry's father, Joseph, a Dijon tax collector, married Agathe Serdet, daughter of a Burgundy Parliament prosecutor, in 1802. Henry's younger brother, Hugues-Iéna, born in 1807, was named for a Napoleonic victory. Joseph died in 1817, leaving Agathe in difficult straits. When their father died, Henry, age 14, told Hugues that he, Henry, would "be the father." He asked Hugues to work hard so they could earn their bread and their mother's honor (P. Darcy, 1957). Agathe expended great effort to educate her sons, and the three remained close for life.

At age 12, Henry won a scholarship that led to further studies. At age 18, he won physics and math prizes and passed the entrance exam to the Ecole Polytechnique, established in 1794 (EP website). After graduation, Darcy entered the Ecole des Ponts et Chaussées (School of Bridges and Roads), and upon completion of his studies, joined the Corps des Ponts et Chaussées, where he spent his entire career.

At the request of the department of Côte d'Or, Darcy was assigned to Dijon in May 1827. In 1828, after promotion to ordinary engineer, he married Henriette Carey, daughter of an Anglican clergyman from the Isle of Guernsey, and sister of a childhood classmate. Henry and his wife had no children.

DARCY'S FIRST PROJECT: WATER FOR DIJON

In the early 1800s, Dijon had a meager supply of poor-quality water. Residents collected rain from rooftops and used well water from a shallow contaminated aquifer. Henry was sickened by the water he drank as a child, and he vowed to do something about it if he ever had the chance (P. Darcy, 1957). He was working in Dijon in 1829 when the city drilled a non-productive artesian well. An 1832 cholera epidemic further underscored the need for water.

In April 1832, the mayor of Dijon asked Darcy to prepare a report on ways to supply water to the city (Lochot, 2003). Darcy tackled the problem with enthusiasm; he studied all water supply ideas proposed since the 16th century and gauged all surface and groundwater resources. He consulted other cities to determine per capita water needs. The Rosoir spring, located in the Suzon valley northwest of Dijon, provided enough water (150 liters/person/day, considered sufficient at the time), and a chemical analysis showed the water to be pure. In 1833, at age 30, Darcy submitted a proposal to deliver Rosoir water to Dijon by gravity through a 12.7-km aqueduct. The French government approved the plan in 1837; land was purchased by 1838. Darcy began construction on 21 March 1839, and water arrived in Dijon on 6 September 1840.

The Dijon distribution system provided free, pure drinking water to 142 street fountains spaced at 100 m intervals. The water was also used to wash streets, flush a stream-turned-sewer that crossed the city, and fight fires. The system was completed in 1845, and the sewer was built by 1847. Dijon became Europe's second city (after Rome) for water quality and quantity.

RAILROAD FOR DIJON

Darcy's first rail transport project, in 1829, was a horse-drawn line to carry coal. In 1832, he was asked to consult on the Paris-to-Lyon rail line, a major artery of the proposed national system. Amidst political controversy, Darcy proposed a route that crossed the divide between Paris and Dijon via a 4.1-km tunnel.

Geologist Elie de Beaumont examined the Jurassic limestone along the route, excavated shafts to inspect it, and declared the rock competent. Darcy's plan was approved; he supervised more than 2,000 workers at the work site from January 1845 until July 1846. For several years, the Blaisy tunnel was one of Europe's

longest. The rail line brought prosperity to Dijon, and the Paris-Dijon TGV uses the tunnel to this day.

LATER YEARS AND THE DEVELOPMENT OF DARCY'S LAW

The March 1848 revolution ended the government that had employed Darcy for 18 years. Darcy was popular in Dijon; he had provided water and the railroad, he was a city councilman and, mindful of human misery, he promoted projects to help the poor. The new regime feared his popularity and, despite protests by the Corps and the city, banished Darcy to a rural area where, during a short stay, he proposed major agricultural improvements.

A new government in June 1848 assigned Darcy to Paris as Chief of Water and Streets. The move gave Darcy a chance to do experiments that had interested him for years. Darcy and other engineers had observed that official formulas did not accurately predict water flow through pipes. So, between 1849 and 1851, Darcy conducted experiments at the Chaillot water plant to study the topic. The results were published in 1857.

In 1850, after promotion to divisional inspector, Darcy studied macadam roads in London and submitted a report on street paving later that year. In 1851–1852, Brussels invited him to consult on its water-supply system and awarded him the Order of King Leopold.

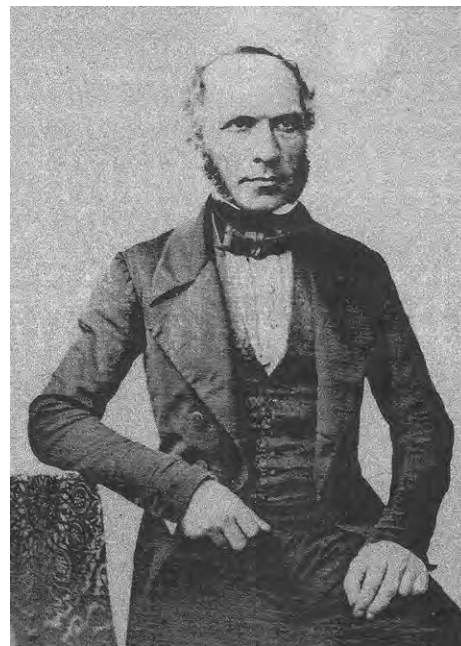
In 1855, after years of poor health and a few months of medical leave, Darcy retired on disability. Even so, he wanted to understand the mechanics of water filtration. In 1854–1855, he set up equipment in the Dijon hospital courtyard and did experiments on water flow through sand. These experiments led to Darcy's Law, which he presented in Appendix D of *Les Fontaines publiques de la ville de Dijon* (Darcy, 1856). His words, in translation, are "Thus it appears that for an identical sand, it can be assumed that the volume discharged is (directly) proportional to the head and inversely proportional to the thickness of the sand layer that the water passes through" (Bobeck, 2004).

Darcy's last project was a Burgundy Canal water-flow study with Henry Bazin (G. Bazin, 2005). During this research, Darcy continued to perfect the Pitot tube, a device used to measure fluid velocity.

Darcy died in Paris on 2 January 1858, at age 54. His body went home to Dijon on the rail line he had proposed, through the tunnel he had built. His admirers carried his coffin to the nearby cemetery. The next day, "Reservoir Square" was renamed "Place Darcy."

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Henry Darcy, circa 1845 (G. Bazin). Courtesy: Collection of Jean Darcy, Paris.

Darcy V and the family for fact-checking the article and for their friendship over the years. I also thank Bob Kent who many years ago suggested I translate Darcy's Public Fountains.

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