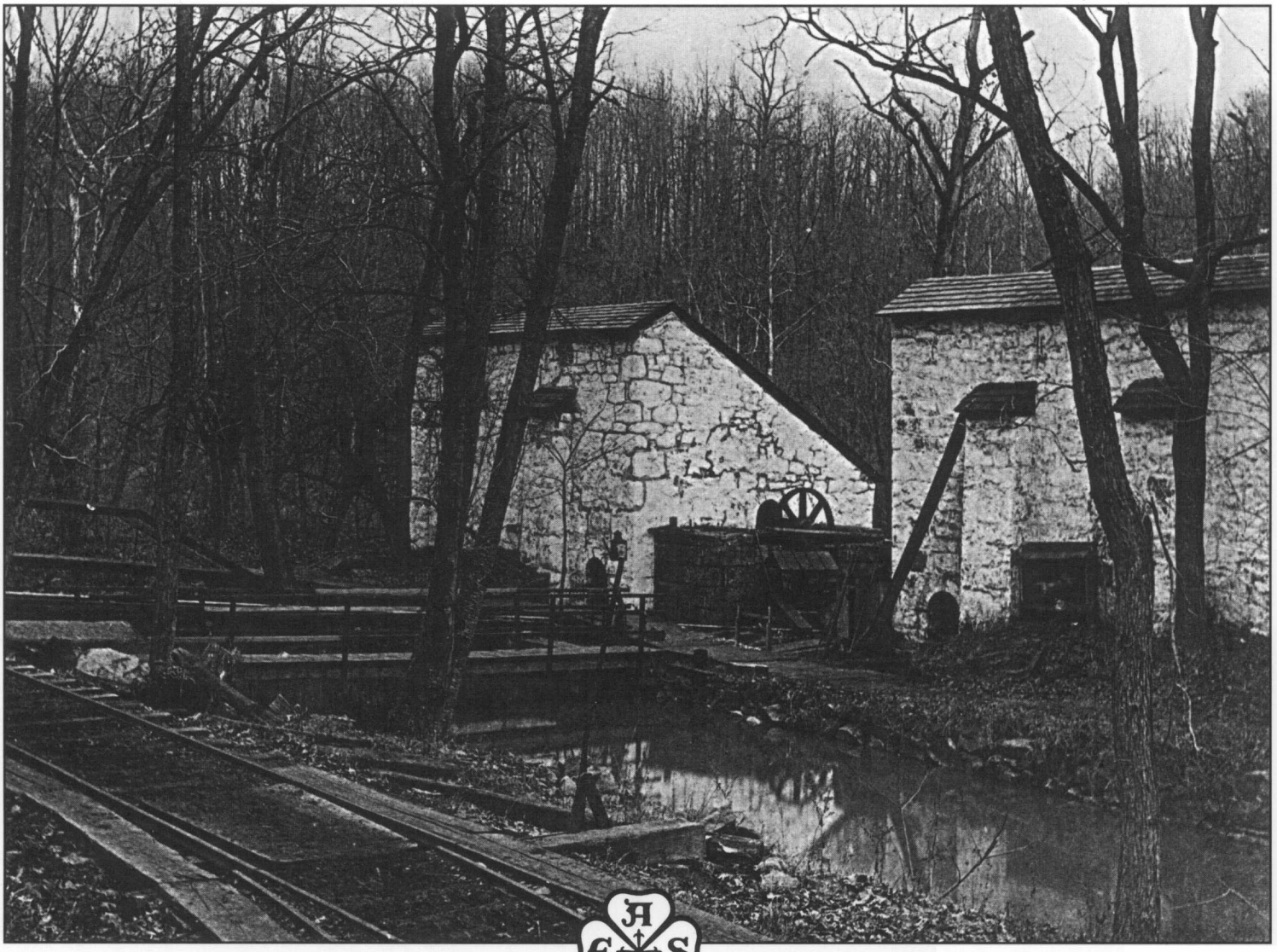
BRANDYWINE

RIVER POWDER MILLS

A part of the Hagley Museum and Library

Historic Mechanical Engineering Landmark



▲ **Birkenhead roll mills, 1822**

The American Society of Mechanical Engineers International
Delaware Section

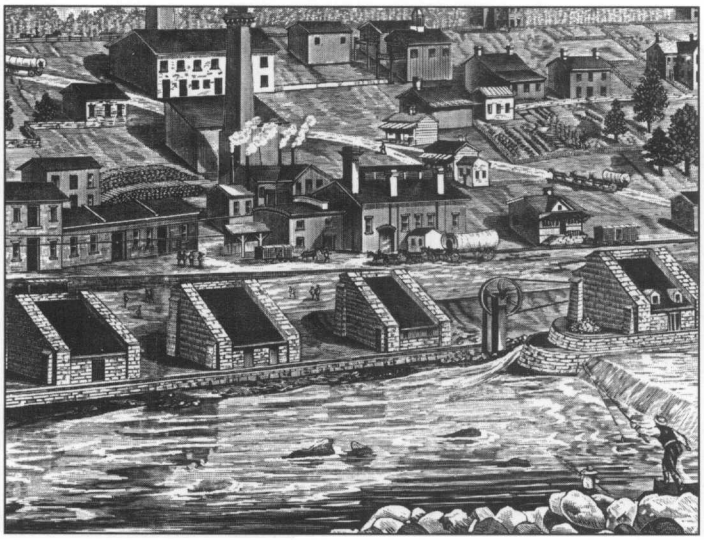
Brandywine River Powder Mills
Wilmington, Delaware
October 9, 2002

Brandywine River Powder Mills

In 1802 a young French immigrant, Eleuthère Irénée du Pont, chose a forested site on the Brandywine River near Wilmington, Delaware, as the ideal location on which to build a high-technology manufactory to produce explosive black powder. The venture posed some clear dangers. New business enterprises are inherently risky, and factories with power-driven machinery were quite rare in the young nation.

Young E. I. du Pont had considerable practical and scientific knowledge, having worked in the French government's black powder manufactory under the pioneering chemist Antoine Lavoisier. The Brandywine site offered an ideal combination of natural features for an industrial operation. Every day 600,000 tons of water passed through the valley (on average), dropping 124 feet in the river's last five miles before encountering the tidal Atlantic. By adding dams across the river and small canals to divert some of its flow, here was latent power to drive a network of mills, with their machinery powered by waterwheels. Extensive granite outcroppings in the valley would provide the stone to build the dams, raceways, and mill buildings. The forested slopes offered up timber to build structures. Local willow was available to make charcoal, a key raw material in black powder.

The market for black powder seemed as expansive as the nation itself, but America had only a few small powder companies, and they produced powder of varying and unreliable quality. The new Brandywine River Powder Mills brought in state of the art manufacturing procedures resulting in cheaper and more uniform power quality. Predictable black powder was necessary for building roads, digging canals, boring tunnels, building railroads, and all mining operations, including coal, iron ore, gold and silver.

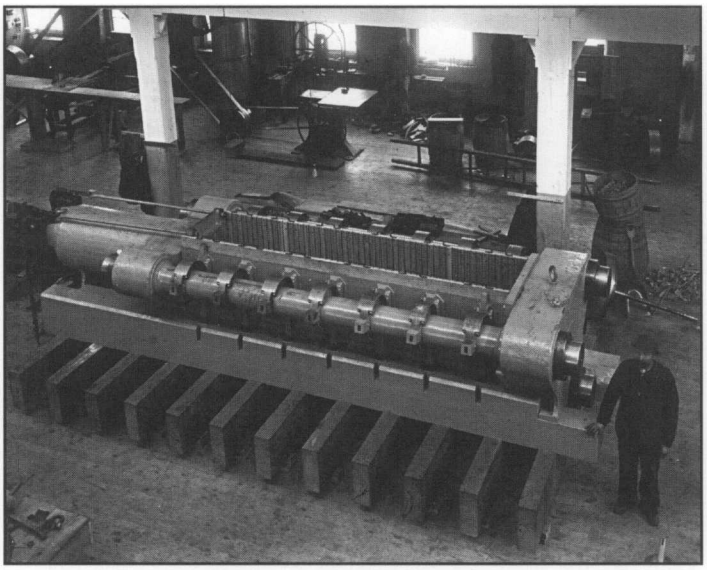


▲ **DuPont Mills from Asher & Adam's Pictorial of American Industry (1876)**

By 1804 the factory was in full operation, producing almost 45,000 pounds of black powder that year. With its innovative adjustable mills, the plant produced powder in a range of different grain sizes, allowing it to meet the needs of different markets, from hunters' muskets to the US Navy's big guns on the *Constitution* and other warships. The firm quickly achieved a reputation for high quality as well; in 1811 Thomas Jefferson wrote from Monticello to praise the superior quality of DuPont black powder.

Safety in production was also of paramount concern. Each stage of production took place in a separate building, allowing closer oversight. This design distinguished the DuPont plant from nearly all other American mills where multiple operations took place in a single building. If an accidental explosion did happen during processing, DuPont's decentralized layout reduced the damage. Furthermore, each processing mill had a design unique to powder making to limit the damage that would result from an explosion. On three sides the mills had heavy stonewalls up to three-feet thick, well buttressed, while the riverside and the roof were of light wood. This design vented the force of explosions toward the river and sky and away from other structures. Other safety measures aimed to prevent explosions in the first place, through rigorous oversight in processing and an ironclad ban on smoking on the premises. Workers who merely possessed matches were immediately fired if caught, and the plant was fenced and gated to keep such contraband out. Despite DuPont's unprecedented regard for safe operations, accidental explosions did occur from time to time, testifying to the inherent dangers of the trade.

In the nineteenth century, the production of black powder entailed mechanical operations, not chemical processes. It consisted of preparing and blending together saltpeter, sulfur, and charcoal with a small amount of water. Workers purified the saltpeter by melting it in large vats. The liquid saltpeter was decanted into other vats and

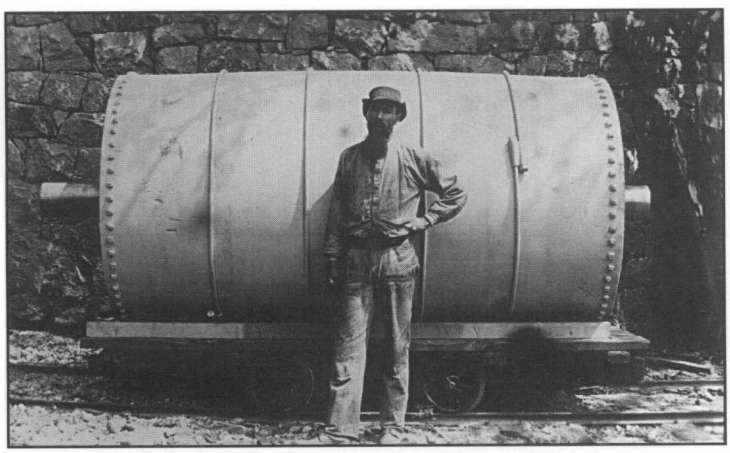


▸ **Black powder hydraulic press in new machine shop**

cooled to form white crystals. Other experienced workers made the charcoal from local willow, poplar, alder, and hazel woods, burning the wood in starved air combustion. Sulfur was sublimated by heating in one closed vessel, with the vapor being drawn into another vessel to cool and liquefy before being collected as a solid. Before blending these materials together, they had to be ground into particles of an appropriate size in water-powered grinding mills. They were mixed in adjacent structures in proper proportions, depending on the end use designated for the powder: muskets, pistols, blasting, or naval guns.

Originally the mixing took place in stamping mills in which the ingredients were placed in depressions hollowed out of a wooden beam. Then wooden pestles, driven by water power, stamped the powder together. Later in the century, the firm installed roll mills (visible at the site today) in which 8-ton vertical rolls mixed the three ingredients, grinding and shearing them as the heavy rolls turned. The powder was then pressed to increase its density. Hydraulically powered horizontal presses, developed by Lammot du Pont, a grandson of the founder, replaced early vertical screw presses driven by hand. Sorting and classifying the resultant powder cake by size took place in the graining or Corning mill, again with mechanical methods, originally with leather sieves and later using rotating classifiers called bolters. The moisture added to powder in the incorporating process was reduced to ½ of 1%. Originally this was done on dry tables or in dry houses. Later improvements combined drying with glazing. The rough edges of the powder grains were smoothed off in the glazing mill. In the pack house, workers gave the powder a final screening, and then packed it into wooden barrels for shipment.

Power to drive these operations came from the waters of the Brandywine. Along the length of its riverside property, DuPont constructed four dams across the stream. All were originally constructed of timber and stone, but one was rebuilt using granite and concrete. Stone-lined raceways directed water to drive machinery in a group of mill buildings, from which the water returned to the river. Sluice gates in the raceways controlled the flow to each mill. Originally wooden waterwheels powered the mills. By the 184Os, more efficient iron water turbines began replacing the wooden wheels. Examples of both technologies are visible at the site today, including a reconstructed 16-foot breast wheel at the Birkenhead Mills. The large waterwheels and the comparatively small turbines, developing upwards of 40 horsepower, turned shafts that powered gear trains to operate the machinery.



▲ **Glaze barrel to finish powder**

Under the successive management of different generations of the du Pont family, the DuPont Company experimented continuously to improve production. Until roughly 1870 water-driven mills accounted for the majority of industrial power in America. In their work with water turbines and their support of institutions like Philadelphia's Franklin Institute, the du Ponts contributed to the development and dissemination of technical knowledge that aided industrial expansion across the country. Eventually the firm turned to steam engines to augment the river's power in the dry summer months and hard winter freezes of the river. Later factory support expansions were entirely powered by steam engines. Here, too, the company took exceptional care to locate its engine and boiler houses far from the production facilities, long line shafts transmitted the power to where it was needed. Raw materials were transported on a narrow gauge railway network that laced back and forth up in the bluffs. Horses and men pulled the small freight cars on rails that were made of wood near the buildings, to prevent sparks. In later expansions, steam engines drove cable drums that pulled cars to the processing buildings higher on the bluffs.

In 1834, the year of E. I. du Pont's death, the mills produced one million pounds of black powder. Rough dates of major events.

1812-1814 - Major expansion downriver helped supply powder for the War of 1812

1822-1824 - Birkenhead Roll Mills built — the first attempt at incorporating ingredients with a roll mill, replacing a stamping mill.

1825 – Erie Canal opened after using DuPont explosive black powder in its construction

Pre 1834 - Dry table for drying powder in the sun. Today the site has one reconstructed table and the foundations of nine others.

Pre 1834 - Glazing mill built

1826 - Date of survey map showing the Eagle Dry House, with its externally heated furnace, on early successor to open table drying

1827 - Built Roll Mills #3 (on the site of the early stamping mill)-4, 5-6, and 7-8.

1828-1829 - Built Roll Mills 9-10, 13-14, 15-16 — rebuilt in 1887

1839 - Old Eagle Roll Mills operational — modernized in 1886, restored in 1973. Today one of only two such exhibits in the world.

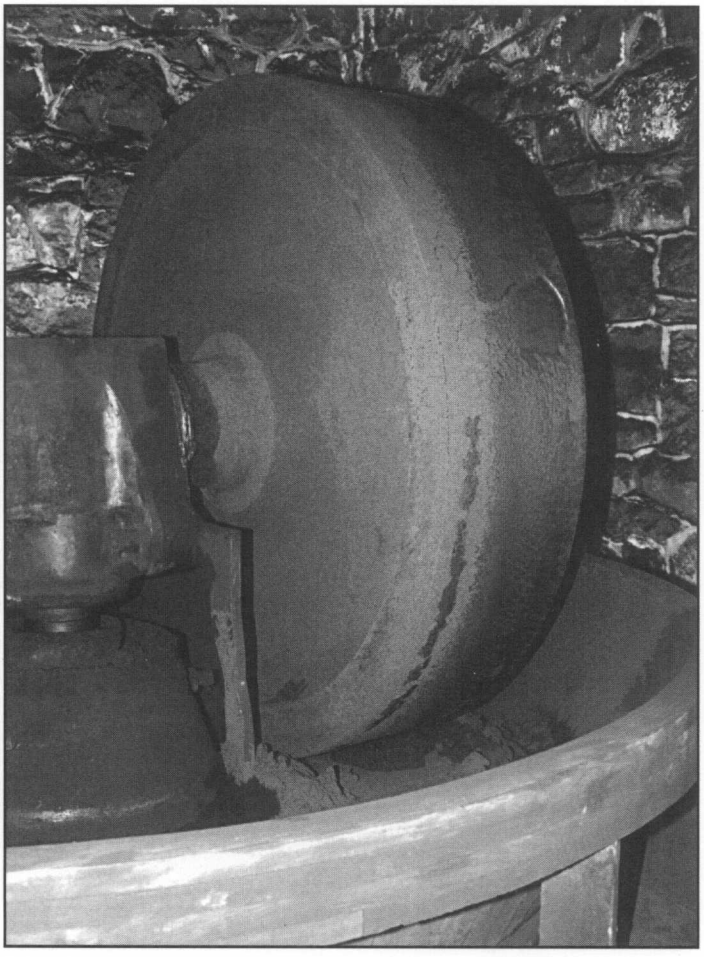
1856 - Roll Mills 17-18 — rebuilt in 1885.

1861-1865 - The Brandywine Mills supply half of all black powder used by Union forces in the Civil War.

Late 19th century - Big Mary Glaze Mill - the largest glaze mill on the property and probably in the world. Originally contained nine glaze barrels each processing over a ton of powder at once.

Despite modernizations, the Brandywine River Powder Mills were largely obsolete by the early twentieth century, but the plant remained in operation through the First World War, supplying gunpowder and loading artillery shells for the Allied nations. Finally shut down in 1921, the mills reopened in 1957 with a new purpose, as a major element in the Hagley Museum and Library, an independent educational institution.

Today the Brandywine River Powder Mills are a superb and rare example of the kind of water-powered mill that was once common. Nineteenth-century grain, cotton, and woolen mills all used similar principles and technologies for power generation and transmission. The Brandywine Mills were the largest powder mills of that era in the US, likely in the world as well. Few such facilities survive today as old powder buildings are normally destroyed to prevent explosions of stray or earth-bound powder. Some of the Brandywine Mills have been cleaned, restored, and reconstructed to show historical conditions; others remain as a ghost of the site's important role in American industrial history. Today the site has largely regained a natural beauty that belies its gritty, industrial past. Within this verdant landscape, the buildings, machinery, and other exhibits show the important role played by the nascent field of mechanical engineering in creating an industrial nation.



◂ **Incorporating roller mill to blend and mix ingredients**

The History and Heritage Program of ASME International

The History and Heritage Landmarks Program of ASME International (The American Society of Mechanical Engineers) began in 1971. To implement and achieve its goals, ASME formed a History and Heritage Committee initially composed of mechanical engineers, historians of technology and the curator (now emeritus) of mechanical engineering at the Smithsonian Institution, Washington, D.C. The History and Heritage Committee provides a public service by examining, noting, recording, and acknowledging mechanical engineering achievements of particular significance. This Committee is part of ASME's Council on Public Affairs and Board of Public Information. For further information, please contact Public Information at ASME International, Three Park Avenue, New York, NY 10016-5990, 1-212-591-7740.

Designation

Since the History and Heritage Program began in 1971, 220 landmarks have been designated as historic mechanical landmarks, heritage collections or heritage sites. Each represents a progressive step in the evolution of mechanical engineering and its significance to society in general. Site designations note an event or development of clear historic importance to mechanical engineers. Collections mark contributions of a number of objects with special significance to historical development of mechanical engineering.

Historical Mechanical Engineering Landmark
Brandywine River Powder Mills
Operative: 1802-1921

Founded by E. I. du Pont, the Brandywine Mills became the largest maker of explosive black powder in the United States. That success resulted directly from its pioneering use of gunpowder processing machinery driven by waterwheels and turbines. Divided into separate buildings to promote safety, its rolling, graining, and glazing mills produced black powder in a range of grades for military, sporting, hunting and construction applications.

The Landmarks Program illuminates our technological heritage and encourages the preservation of the physical remains of historically important works. It provides an annotated roster for engineers, students, educators, historians, and travelers. It helps establish persistent reminders of where we have been and where we are going along the divergent paths of discovery.

The 125,000-member ASME International is a worldwide engineering society focused on technical, educational, and research issues. ASME conducts one of the world's largest publishing operations, holds some 30 technical conferences and 200 professional development courses each year, and sets many industrial and manufacturing standards.

Bibliography

The Evolution of the Process of Powder Making from an American Prospective by Robert A. Howard, Chapter 1 in *Gunpowder: The History of laternational Technology* by Dr. Brenda Buchanan ISBN .0-86197 124 B Bath University Press 1996

Realities and Perceptions in the Evolution of Black Powder Making by Robert A. Howard for International Council on History of Technology (ICHOTEC-4) held in Portugal.

Personal conversations with Robert A. Howard, retired Curator of Engineering and Technology at Hagley Museum and Library

Explosives in History by Norman B. Williamson, Pamphlet

http://www.chemheritage.org/HistoricalServices/eminentchemists/eidupont.htm

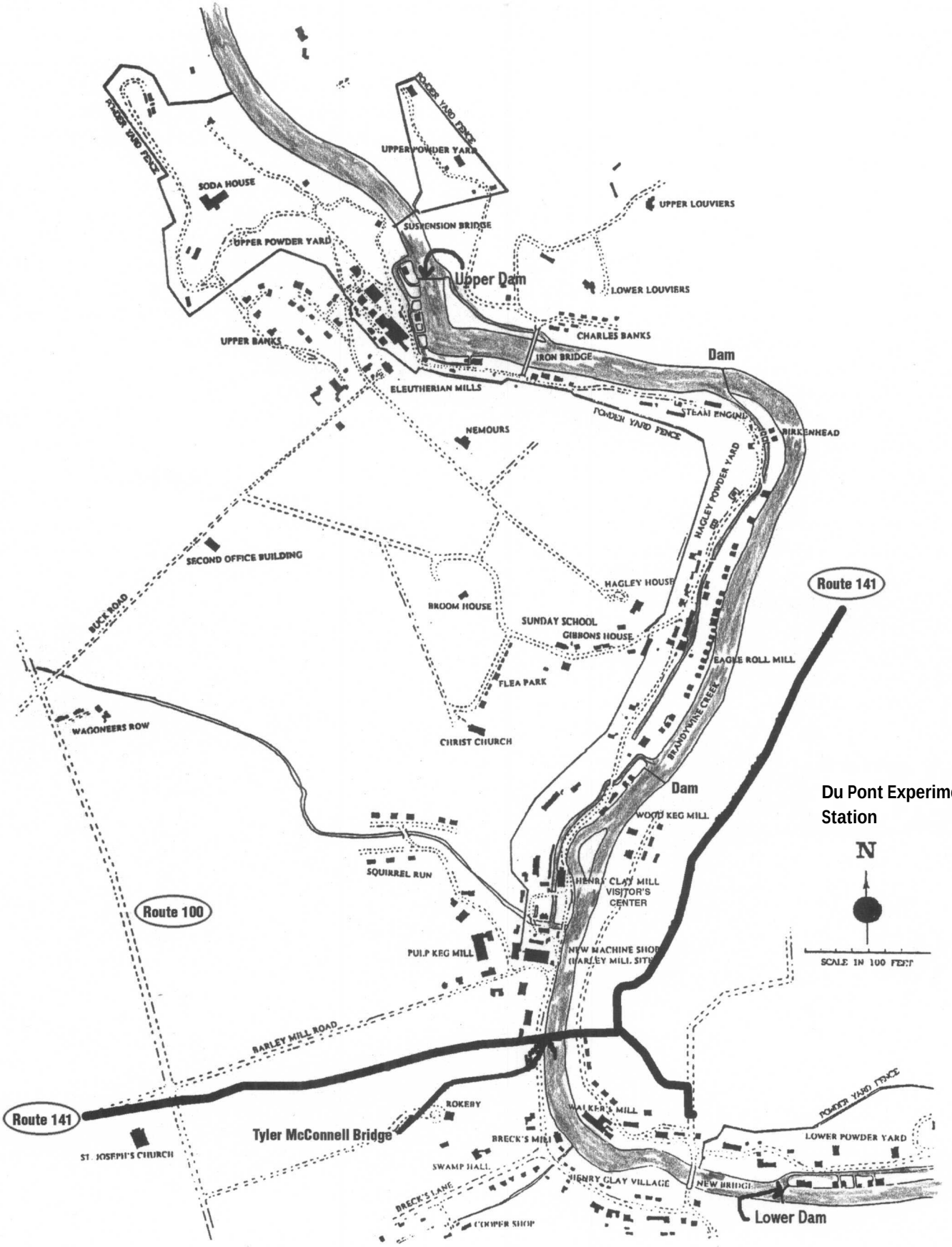
The Hagley Museum and Library has the best collection of reference materials on black powder as well as the best collection of letters, papers, and details of the early DuPont Company. It is suggested that some one interested in further information contact the Library at their website to view their index of material both in their library and their Soda House, which contains family and early company records. The Library web address is http://www.hagley.org.

Acknowledgements

Grateful acknowledgment is given to the executives and staff of the Hagley Museum and Library for their assistance and courtesies throughout the project. The pictures in this brochure were used with their kind permission.
Acknowledgement and thanks are given to Robert A. Howard for his assistance and encouragement.

▲ **16'Water wheel for roll mills**

Map of Brandywine River Powder Mills – with present (2002) locations of Du Pont Experimental Station and Tyler McConnell bridge



H221