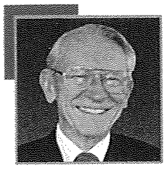


The Historic Mechanicville Hydroelectric Station

Part 1: The Early Days

James A. Besha, Guest Author

In 1894, the Columbian Exposition in Chicago showcased the marvel of electricity and its ability to provide light and power. With a new century on the horizon, a tide of optimism swept the United States, compelling inventors to advance technology, engineers to implement it, and industrialists to capitalize on it. The industrialist and early hydroelectric pioneer Robert Newton King exemplified all three.

Project Development

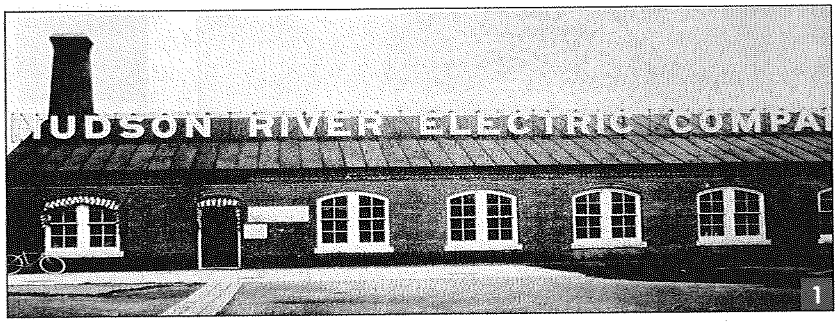
King, president of the Stillwell-Bierce & Smith-Vaile Manufacturing Company of Dayton, Ohio, joined with others in surveying the water power potential of the Hudson River, just 20 miles up river from Albany, the capital of New York state. The site featured rapids alongside a large tract of undeveloped land. Others had previously recognized the site's power-making potential, as a small wing dam and sawmill had been constructed there in the 1800s, but King's plan would dwarf those earlier structures.

King and his advisors selected this site as much for its proximity to the burgeoning industrial areas of Albany, Troy, and Schenectady as for the hydroelectric power potential of one of New York's largest rivers. The Hudson River drains 4,620 mi^2 of upstate New York, including the Adirondack Mountains, and could be expected to provide a substantial and reliable source of water to power the growing industrial needs of New York's Capital District. On 6 July 1895, the local newspaper, *The Mechanicville Mercury*, commented that water power "could be developed at a very small cost and it is a surprise to us that the long-headed capitalists of Albany and Troy have not yet discovered this veritable gold mine."

Construction on King's dream was initially delayed by the economic depression of the early 1890s but finally commenced on 24 July 1897. Completion was optimistically predicted for the end of 1897. Unfortunately, a massive storm on 1 November 1897 raised the modest seasonal flows of the Hudson River to a powerful torrent that destroyed the project cofferdams and much of the main dam. King was not one to be deterred. He doubled the construction effort by employing over 400 men in an aggressive 24-hour-a-day, seven-day-a-week push to move the project to completion.

The plan succeeded brilliantly. Just a few months later, on 29 May 1898, the first of seven turbines and generators was tested. Commercial operation commenced and power was generated and transmitted to the General Electric plant in Schenectady on 22 July 1898.

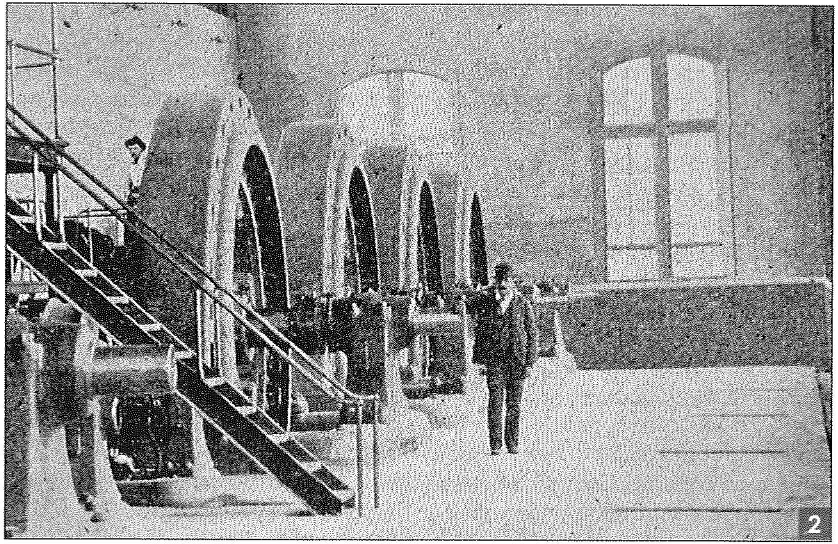
> EACH OF THE SEVEN GENERATORS AT THE MECHANICVILLE PLANT COULD PROVIDE 750 KW.



The Mechanicville Hydro Plant as it appeared in 1898. (Figure courtesy of Albany Engineering Corporation.)

Each of the seven generators at the Mechanicville Plant (see Figure 1) could provide 750 kW (a total of 5,250 kW), and about half of all electric power from the plant was contracted to the General Electric (GE) plant. It is not clear from the surviving records whether GE was simply the supply vendor for the generator and purchaser of 3,000 kW or if the company had a financial interest in King's Hudson River Power Transmission Company. Regardless, GE's relationship with the plant ran deep. Charles Proteus Steinmetz, the "wizard" of GE and the father of modern electrical engineering, designed the generation arrangement as well as the power transmission systems that connected the Mechanicville Hydroelectric Station to the Schenectady General Electric Company.

King's Stilwell-Bierce & Smith-Vaile Manufacturing Company supplied the seven original turbines. They were Victor-type, quadruplex Francis units with four runners, each with a 41-in diameter and 250 HP, ganged together on a single shaft and running at 114 r/min. Each turbine was coupled with a horizontal GE rotating field generator with 40-pole, 12,000-V stators to achieve a supply frequency of 38 Hz when operating at 114 r/min.



The generator hall in 1898. (Figure courtesy of Albany Engineering Corporation.)

Initial Operation

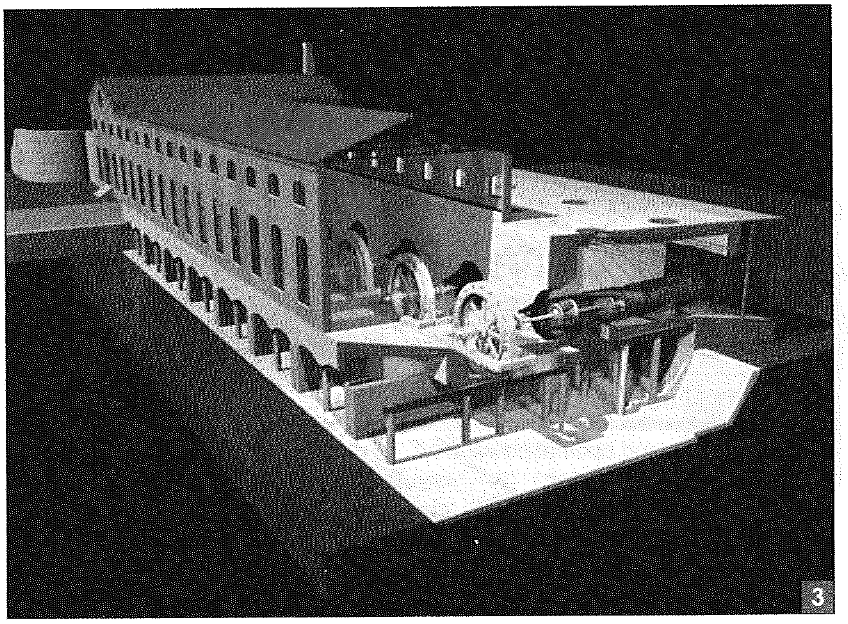
The five original turbines were all in full operation by 27 August 1898 (see Figure 2). Two more turbines had been ordered but were not yet installed when all seven turbines were replaced with turbines manufactured by S. Morgan Smith Co. in

1902. The new turbines utilized the same open flumes, draft tubes, bulkhead cases, and generators, but they were rated for 1,250 HP (four runners at 312.5 HP each) at the same head while rotating at 125 r/min. Exactly what prompted the early and sudden replacement of the turbines is something of a mystery.

By 1900, a new company, called the Hudson River Power Water Power Company, led by Eugene Ashley, a local attorney and developer, had replaced King as the proprietor of the enterprise. King's turbines were replaced by Ashley's choice of turbines, which were of virtually identical design. Apparently, at this same time the water inlet to the turbine open flume was also modified. The inlet had originally been framed as a concrete arch. A significant amount of the 4-ft thick concrete wall that had framed the arch was removed, expanding the inlet. This greatly improved the hydraulic passageway and reduced the hydraulic head loss into the turbine chamber.

So, was the original turbine selected by R.N. King sufficient, lacking only the proper civil works to perform? Or was the turbine change out required to increase the output frequency from 38 to 40 Hz? Or, was the replacement with virtually identical units a boardroom maneuver to oust King, the original turbine supplier and founder of the enterprise? While we don't know the answer to the last question, we do know that King, who died in 1943 at age 97, was not discouraged by the change and went on to become a very successful financier in both the power and petroleum industries.

Concurrent with the very early turbine replacement, a Corliss steam engine was installed in the powerhouse to power the No. 7 generator through a somewhat jury-rigged rope-drive arrangement. This installation lasted only about five years and was an apparent attempt to augment low river flow conditions with coal-fired steam power.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A cross-section illustration of the powerhouse showing the generator hall, turbine deck, turbine chambers, and waterways. (Figure courtesy of Albany Engineering Corporation.)

Civil Works

The design of the hydraulic works is comprised of three elements: a concrete ogee spillway, 900 ft in length and 8-12 ft in height; a nonoverflow earth embankment dam about 900 ft long and approximately 20 ft in height with a concrete core wall; and a powerhouse 220 ft long and 50 ft wide with an integral intake, waterbox-style turbine chamber, draft tube chamber, and generator hall. The powerhouse also includes office space, storage areas, and an assembly bay.

The powerhouse structure is comprised of an unreinforced concrete foundation and hydraulic conveyance structure with a triple wythe brick masonry exterior fitted with more than 100 wood sash windows. The steel roof trusses and craneway are supported on steel columns built up from angle and tee shapes. The original steel roof panels, now over 109 years old, are supported by a pine roof deck with a slope of 4 on 12. The steel roof has survived this long because it has almost never been subjected to snow and ice because of the abundance of thermal energy coming from the generator hall beneath. While this style of powerhouse design is now very familiar to hydroelectric engineers, it was one of the first of its kind and served as a model for the many that followed.

The powerhouse is divided into two parts by a 6-ft thick concrete headwall. Upstream of the headwall are the turbine chambers for the seven main machines and two exciter turbines. The turbine chambers are each 32 ft, 6 in long by 22 ft wide. The ceilings of the turbine chambers appear to be unreinforced concrete arches. However, structural analysis has shown that the roof actually functions as a deeply haunched simple beam with loading stresses well distributed and well below acceptable levels for unreinforced concrete. Similarly, the draft tube chambers were formed with an arched ceiling supported on concrete walls. The arched ceilings of the draft tube chambers, which serve as the floor of the generating hall, also act as a deeply haunched simple beam.

The arrangement of submerged, open-flume-type turbines with multiple water wheels ganged on a simple shaft that connected through a packing box to horizontal generators located in a generator room considerably diminished the required size of the powerhouse. The Stillwell-Bierce & Smith-Vaile Company patented this design arrangement.

The office and hallway area on the upstream side of the powerhouse retains its original pressed tin ceiling, chestnut wainscoting, long leaf pine floors, and molded brick fireplaces. The interior walls and ceiling of the main generator hall were whitewashed. This complemented the white marble windowsills and produced a bright white radiance from the sun streaming in through the many windows along the south-facing downstream wall.

Mechanicville Today

Today, six of the seven "original" turbines are still attached to the original 1897 generators (see Figure 3). One turbine (Unit No. 6) failed in 1932. This unit was not repaired and was removed from the turbine chamber. Through extensive restoration efforts that began in mid-2003, five of the generating units are operating today to deliver clean, renewable hydroelectric power to the transmission system. There is so little vibration in the generating units that a coin placed on the generator bearing housing can balance on its edge while the unit is operating. Because the plant continues to generate at 40 Hz, output must flow through a pair of rotating frequency changers.

The two original 1897 Stillwell-Bierce & Smith-Vaile exciter turbines with fly-ball hydraulic governors, each consisting of 3- to 18-in wheels on a common horizontal shaft, are still in place, although they are no longer used. They were originally used to drive the 125-V, 250-kW dc alternators to excite the main generators. For approximately the past 50 years, this function has been provided by a separate static excitation system located beneath the switchgear on the generator floor.

The original S. Morgan Smith turbines are open flume, horizontal Francis-type quadruplex machines (four runners on a common shaft). A horizontal cast iron cylinder controls the flow of water to each of the runners. The linear motion of steel rods through a rack and gear mechanism within the powerhouse activates the cylinders. There are two types of turbine shaft bearings. Four wooden water-lubricated bearings (lignum vitae) are located within the water chamber, and a single oil bath babbit bearing is located outside the water chamber. The turbine shafts are direct flange-coupled to the generator, which also runs on oil bath babbited sleeve bearings. The original turbine thrust bearings were also water-lubricated lignum vitae within the water chamber. These still exist but have been somewhat modified, although lignum vitae is still being used as the primary bearing surface. Water lubrication to the wooden bearings is simply through immersion. When they are properly maintained, the life of these wooden bearings can be measured in decades. Maintenance includes little more than adjustments twice a year. Originally, this adjustment was probably performed using a tight-wire method. Today, we use a laser.

Turbine operating control was originally provided by a Geisler dc-driven electromechanical speed governor. This design did not stand the test of time and was replaced by a Lombard hydraulic governor in approximately 1902. These speed control governors operated until 1950, when the need for independent speed control diminished. The fly-ball governors were removed, and the hydraulic cylinder operating mechanism was used simply as a gate actuator to rotate the pinion gear for the rack and pinion turbine gate control.

After 109 years of continuous operation, the Mechanicville Hydro Plant is believed to be the oldest continuously operating hydroelectric generating facility in North America. It stands as a tribute to good engineering, the dedicated efforts of maintenance personnel over the years, and the commitment of its current owners to continue to provide clean, renewable electric power from this historic facility.

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