Society for Industrial Archeology · New England Chapters

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MEMBERSHIP INFORMATION

The Society for Industrial Archeology promotes the identification, interpretation, preservation, and modern utilization of historic industrial and engineering sites, structures and equipment. For information or to apply for membership to the Northern NE Chapter (ME, NH, VT) contact Richard Russack at RickRussack@gmail.com; or, to the Southern NE Chapter (MA, RI, CT) contact William Goodwin at ngoodwin@earthlink.net.

Newsletter Numbering Errors

Currently the Newsletter is being published twice a year; in the Spring and Fall. Each year has been given a sequential volume number, and the two issues each year are numbered 1 (Spring) and 2 (Fall). There have been errors made in the volume numbers for the Fall 2007 and the Spring 2008 issues. The **Fall 2007 should be Volume 28, Number 2** (it is marked Volume 29, Number 2), and the **Spring 2008 issue should be Volume 29, Number 1** (it is marked Volume 30, Number 1).

SNEC-NNEC Symposium to be held at Clark University in Worcester February 21, 2009

The 21st Annual Symposium on Industrial Archeology in New England will be held on February 21st at Clark University in Worcester, MA. Registration starts at 9:00 AM at the Jefferson Center. Abstracts for presentations may be sent to Bob Stewart at robert.stewart13@att.net The event will conclude at 4:00 PM.

NNEC-SIA President's Note

Our chapter has been hosting some very good tours of industrial archeology sites lately and I encourage all members to try and attend them. For our Spring tour which normally takes place between mid-May and early June, we have many hours of daylight after the tour ends, allowing members to drive longer distances home in daylight. But in the fall, darkness can often arrive an hour after our Fall meeting and tour ends. This makes it more difficult to drive across NH for a day in Vermont or Maine.

With this in mind, we may better serve the members by having our spring tours, when possible, in Maine and Vermont. This would not be possible all the time, but should increase participation of the tours in Vermont and Maine due to longer daylight hours in the morning and more importantly, after the tour ends. NH would be a better location for fall tours due to shorter driving distances for members from

Vermont and Maine. This pattern would not be feasible every year, but is a suggestion when a site can be visited at either time of year. For the past dozen years, approximately half the tours have been in NH, so this proposal would not increase the number of tours in NH, but rather try and move them to the fall, if possible. Some years, like this one, both our tours and meeting will be held in Maine and Vermont/Eastern NY.

One more note is we need to be thinking about converting some of our operations over to email like all other organizations. In the future, we can use email to contact members regarding membership renewals, meetings and tours, and the Plymouth Winter Conference. All officer positions are voluntary, most if not all of us are working, and it takes a considerable amount of time to send membership renewals to all members every year, along with the meeting and tour fliers. The fewer mailings that take place, the easier it is for the chapter officers to remain in their positions by reducing the workload.

Some members may never have email and will still be mailed all information. However, from sign-up lists on recent tours, it appears that over 90% of members do have email. When the next membership renewal notices are sent out, please write in your email address. It may take a couple of years to implement, but eventually we'd like to be able to send chapter members information via email concerning changes in tours (like Fall 2007), or other interesting events that would be of interest. Here's an example: Prof. Joel Eastman who led our Spring 2008 tour was leading a tour in June 2008 of the island forts in Portland harbor. He thought some of our members would be interested and to let all members know about the tour. But I had no complete list of members' email, or knowledge of how to do it. I plan to learn how to send out mass emails of interesting events related to industrial archeology, and if chapter members send in their email address, we'll be ready next time.

Dave Coughlin
President, Northern New England Chapter

NNEC-SIA SPRING 2008 TOUR

A very interesting tour of the Cumberland and Oxford transportation canal was the focus of our spring gathering. Prof. Joel Eastman who has studied this canal for decades was our tour leader. Additional information was provided by Bill Gerber of the Middlesex Canal Association and he has researched the boats used on this canal.

The canal operated from1830-1872 and was the longest transportation canal in Maine. It ran 15 miles from Sebego Lake along the floodplain of the Presumpscot River ending at the coast at Casco Bay near Portland. Cargo could be brought to Sebago Lake from Long Lake, extending the distance cargo could be hauled by the canal boats. These boats had one or two masts for sailing on Sebago Lake and along the Maine coast. The masts were lowered down when being towed by a single horse on the canal. Boats were generally 65 ft. long and just under 10 ft. in width to fit into the 70 ft. by 10 ft. locks. Cargo capacity was 20-30 tons with 20 locks being built on the canal. The depth of the canal was only 4 feet with a width of 34 ft. on the surface and 18 ft. on the bottom.

Portions of the canal and locks are still visible today. We made stops to view the canal, locks, turning basin near the coast, and the former canal basin where repairs were made. Despite having been closed for over 135 years, the wooden posts of a lock gate were still visible at one site. Cargo hauled to the coast would have included lumber, firewood, numerous forest products, farm goods, and other items from the countryside. The return trips would bring manufactured products, furniture, liquor, etc. The trip downstream to the coast would take one day and the upstream return two days back to the Maine interior.

At its peak, there were 150 canal boats on the C & O canal. By 1846 the railroad began making inroads from the coast, stopping at the same towns as the canal: Gorham, Windham, and Westbrook. Rail freight was faster, cheaper, and ran in winter. By 1850, after 20 years of operation, the best days of the canal were over. It hung on, with limited maintenance and use, for another 20+ years, finally closing in 1872.

An interesting stop was to view the remains of the Oriental Powder Mill complex, next to the canal and operating from 1824-1905. A tour of the site was led by Maurice Whitten, who has written a book on the gunpowder mills that once existed in Maine. Remains of a wheel type powder grinding mill is still visible and the site has been cleared for observation. Waterpower from the Presumpscot River and later the canal after it closed was used to power waterwheels and turbines in the manufacturing buildings. Today only foundations exist, including that of the pressing mill which pressed 3-4 inches of gunpowder into 1-inch-thick cakes. The manufacturing buildings were kept apart from each other to lessen the effect of fire and explosions. During its 81 years of operations there were 28 major explosions, with house windows frequently being shattered miles away. A very dangerous place to work. Approximately 25 percent of the gunpowder used by Union troops during the Civil War came from this site. The mill complex was sold a few times over the years, with Dupont now holding all the original records.

Dave Coughlin
President, Northern New England Chapter

MEETING ANNOUNCEMENT

The Dorchester Historical Society will host the Tide Mill Institute's fourth annual Tide Mill Conference on November 7 and 8th, 2008. The conference begins with a reception from 6:30 to 8:30 p.m. on Friday evening, November 7th. A day-long conference will take place on Saturday, November 8th. Please contact Earl Taylor for details at 800 663-6063 or ERMMWWT@aol.com

A tide mill is quite simply a water mill that derives its power from the rise and fall of the tides. Water impounded behind a mill dam can only be put to work after the water level outside of the dam has sufficiently dropped during the ebb tide. Wherever there was an absence of freshwater streams, or where freshwater streams had an inadequate drop in geographic elevation, tide mills were important early industrial resources in many coastal areas.

Mission of the Tide Mill Institute www.tidemillinstitute.org:
• to advance appreciation of the American and international heritage of tide mill technology;
• to encourage research into the location and history of tide mill sites;
• to serve as a repository for tide mill data for students, scholars, engineers and the general public and to support and expand the community of these tide mill stakeholders;
• to promote appropriate re-uses of old tide-mill sites and the development of the use of tides as an energy.

SNEC-SIA SPRING 2008TOUR
Storrs & Mansfield, CT
Date: Saturday, May 17, 2008

Tour Summary
Southern New England Chapter's spring meeting and tour took place in Mansfield, CT, where members had special tours of a state-of-the-art document archive facility, Connecticut's only stone grist mill, and a guided tour INSIDE a flood control dam. The weather was ideal for traveling and exploring each of these places, and members had a good taste of rural northern Connecticut.

SNEC-SIA members first met in the building of the Thomas J. Dodd Research Center on the main campus of the University of Connecticut in Storrs, a part of Mansfield. The Dodd Center was built in 1995 and named after Thomas J. Dodd, former Senator for Connecticut, and father of the state's current Senator, Christopher Dodd. The facility contains special university documents, children's books, corporate records, photographs, maps and engineering drawings, and other industrial documents. After people had breakfast and talked with one another, we gathered into the entrance to the library. Laura Katz Smith, Curator for the library, and our tour guide, made opening remarks, and then took us to the archiving and storage areas normally not seen by people visiting the library. She first led us to the receiving area. The receiving area had a cold room where documents that were damp or contained mold were placed to dry out the documents and kill any mold, which not only deteriorates the document it grows on, but spreads quickly to other nearby documents. She then led us to one of the floors that hold the collections. The library has three floors, 8,000 square feet, each, for a total of 24,000 square feet of storage space. The collections are contained in movable shelves. We returned to the public area where Laura brought out samples of the library's collections. These included engineering plans of specific locations of the New York, New Haven, and Hartford Railroad, photographs of early telephone maintenance crews from the Southern New England Telephone Company (several showed wagons pulled by horses!), and files of area mills and companies. After more discussion about how the library maintains its collection, the group had a brief meeting, and then broke for lunch.

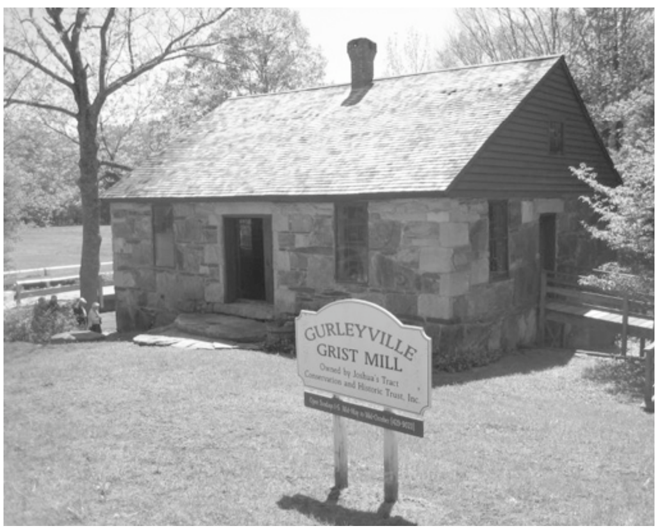
After lunch, the group reconvened at the Gurleyville Grist Mill about 2.5 miles east of UConn. There, Bruce Clouette provided a detailed tour of the mill and the site of the dam along Fenton River. The present stone building was built in 1835 on a site with gristmill and saw mill activity at this location as far back as 1723. It is claimed that this stone mill is the only one of its kind in Connecticut and one of only three standing in New England, and, much of the original machinery remains intact. Bruce talked and demonstrated many of the tasks that were done in the mill, including how to take out and redress the grinding wheels, sift flour, and remove corn from the cob. Below the main floor, he showed how the shafts and gears transferred power to the machinery above and pointed where the water from the brook would have flowed under the mill. Outside, he traced where the dam would have been (the 200+ year-old dam was breached by a storm in 1959). The group had a few minutes to explore the dam and mill before heading on to the Mansfield Hollow Dam about 5 miles away.

Along the way, the caravan passed by a historical sign for the O. S. Chaufee and Sons Silk Mill that once was located on the Fenton River. No time to make a stop, this time!
At the Mansfield Hollow Dam, we were greeted by our tour guide from the U.S. Army Corps of Engineers, who led us inside the structure. The dam was completed in 1952 as one of several built in the area to control against floods. This one collects water from the Natchaug River, Fenton River and Mount Hope River and controls the flow of the Natchaug River downstream through Norwich, Connecticut. The dam is an earthen rolled levee that has a spillway 690 feet long and 62 feet high. Though there was much controversy over the need of the dam up to the time it was built, its need was demonstrated in 1955 (a hurricane) and 1982, saving lives and property. Today, the lake behind the dam is used for boating, fishing, and other recreational use. Our guide had initial remarks about the dam in the first room, and then we descended one flight of stairs to a room where the pneumatic pumps that operated the gates was located. After the guide explained the system, we walked into the corridor INSIDE the spillway. This corridor was noticeably cooler than the warm air outside! The corridor led to the gate controls and gate housing near the center of the spillway. After walking to the outside, we climbed more stairs and walked outside to view the spillway from the other side. After we had our fill, we again descended into the corridor and returned.

After touring the dam, members were invited to explore the brook downstream, including the dam and building of the Kirby Mill, which was used at various times to make cotton thread, optical parts and accessories, then various metal products until it was closed around 1950.

It was a full day and well worth the trip. Many thanks to the organizers and guides: Laura Katz Smith, Curator for Business, Railroad, Labor and Ethnic Heritage Collections, Thomas J. Dodd Research Center, University of Connecticut, Storrs, CT; Bruce Clouette, Guide, Gurleyville Grist Mill; Dave Poirier Staff Archaeologist, Connecticut Commission on Culture and Tourism (SHPO); Jason Robinson, U.S. Army Corps of Engineers, Mansfield Hollow Dam.

The granite industry was (and is) strongly dependent on



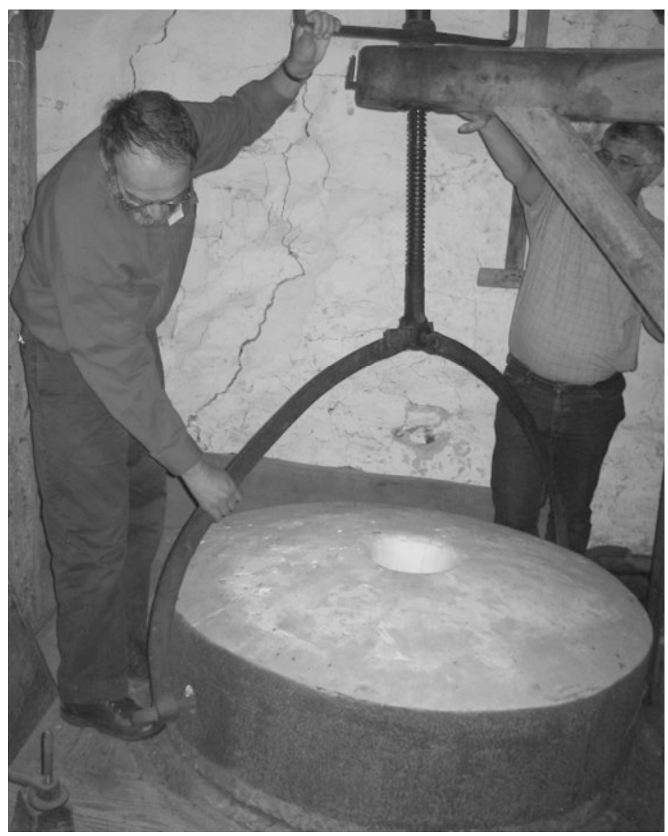
Links:

http://www.lib.uconn.edu/online/research/speclib/ASC/ (web site for the Thomas J. Dodd Research Center)

http://www.joshuaslandtrust.org/gristmill.html (web site for the Joshua Land Trust, with a page for the mill owned by them)

http://www.nae.usace.army.mil/recreati/mhl/mhlnat.htm (US Army Corps of Engineers' website for the Mansfield Hollow Dam)

Craig Austin
Secretary, Southern New England Chapter



Power Sources for the Granite Industry

the availability of power for the efficient quarrying, finishing and transport since granite is heavy (170 lbs. per cubic foot) and very difficult to work. Roughly, from the mid 19th century to the mid 20th century, the granite industry progressed through manual power, draft animal, water wheel, water turbine, steam engine, steam turbine, compressed air engine, electric motor, and internal combustion engine. It is nothing less than an historical parade of this nation's principal sources of power.

The basic problem is the conversion of energy from various sources (draft animals, falling water, burning wood or coal, etc.) into motive power and then transmitting that power to the granite working and moving machinery. The cost of power is typically only a small part of the total cost of a granite operation but it is a critical part – any power interruption can shut down the entire manufacturing process. Granite companies need continuous power for continuous operation and power reserve to meet peak demands. Granite became a major nation-wide industry only after the introduction of highly efficient tools and machines and the availability of reliable power to run them. In the end, the choice of a power source depended on the scale of the granite operation, the number and size of local water power sites, the local availability and cost of fuel, and the possibility of sharing power sources with other local industries.

Initially, the quarrying, lifting, moving, and finishing of granite were manual operations. Granite was quarried with hand tools such as the hand drill, drilling hammer, and wedge and shims. Granite was lifted and moved by lever, hand-operated derrick, sledge and rollers. Granite was finished with hand tools such as the hand hammer and chisel. Manual granite quarrying and finishing was a slow and costly process and only relatively small granite pieces could be lifted and moved. Except for coastal quarries where boat transport was available, granite markets were limited to areas within a few miles of the quarry. The granite products were relatively simple – mostly stones for foundations, hearths, steps, sills, lintels and posts. Next, draft animals (horses and oxen) were employed under human guidance to lift, move and transport granite. A horse could provide a continuous one-half horsepower whereas a man could produce only about one-eighth continuous horsepower. The upkeep cost of a horse was about the same as the salary of a skilled worker. Quarry overburden was removed by ox shovel and wagon. Lifting of quarry blocks

Figure 1. *Horse Sweep-Powered Derrick Hoist, Barre, VT.*

Figure 2. *Riverside Granite Polishing Mill Powered by Water Turbine, Hardwick Granite Co., Hardwick, VT.*

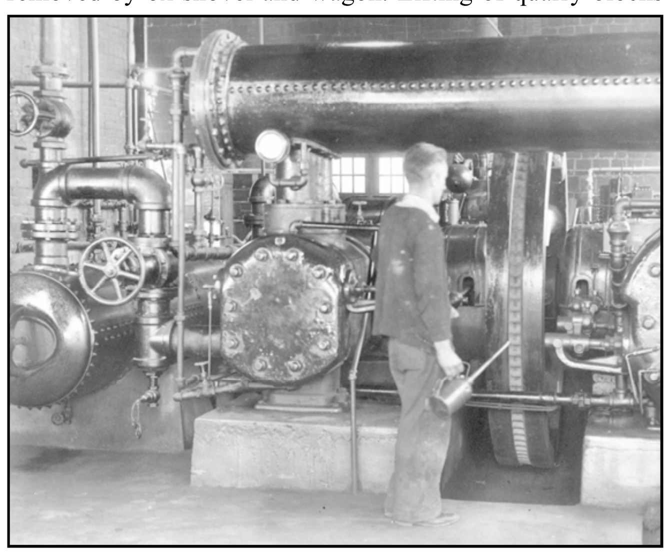


Figure 3. *Steam Turbine-Driven Two-Stage Air Compressor, Jones Bros., Barre, VT.*

Figure 4. *Shay Geared Locomotive No. 2, Hardwick & Woodbury RR, Hardwick, VT.*

was done by horse sweep-powered derrick hoists (Fig. 1) and transport was accomplished by horse and ox-drawn wagon or, during winter, by sled – sometimes aided by block and tackle for very steep or muddy roads. Now, granite blocks of many tons could be lifted and transported.

The granite industry followed the factory system pioneered by the textile industry in the early 1800s in Waltham and Lowell, MA. This included the use of water and later steam power, the integration of all manufacturing steps in one building, automated production by complex machinery, and distribution of power to machines located throughout the building via millworks. Granite finishing sheds were at first (prior to the use of steam engines) located at waterpower sites at a rapids or water falls on streams and rivers for which the granite company had purchased the water rights or mill privilege. A millrace (or headrace) was used to channel water from a dam to a water wheel (overshot, breast or undershot) which was connected via a millwork (shafts, pulleys and belts; cranks and rods; cams and lifters; or gears) to the various granite-working machines such as gang saws, polishing machines and lathes. For low water flow and heads of ten feet or more usually the overshot wheel was used. The breast wheel could be operated for a range of lower heads but required a larger water flow. The undershot wheel could be operated with a small head by utilizing the force of the stream flow itself but required a large water flow. A water wheel has the virtue of simplicity – it has only a single moving part, can be made almost entirely of wood, and can be constructed by traditional craftsmen such as millwrights, carpenters and blacksmiths. No precision parts, enclosure or flywheel are needed. Water wheels rotate slowly – the larger the wheel the slower the rotation. They mostly range in diameter from eight to thirty feet with rotation speeds of twenty to five RPM. As a result, one of the tasks of the millwork was to increase the rotational speed (by belts, pulleys and gears) to that needed by the granite-working machines.

Later, by about the 1850s, water wheels were increasingly replaced by water turbines which ran at higher speed and produced more power (Fig. 2). In addition, turbines were compact, durable, efficient and low cost. Whereas water wheels were made primarily of wood, turbines because of their design complexity and the required strength and close tolerances were made of iron and were manufactured at distantly-located factories. The turbine operated with water under pressure conveyed from a dam via a wooden or iron penstock. Since turbines were oriented horizontally with vertical shafts, bevel gearing was used to transfer power from the turbine shaft to the horizontal main shaft of the millworks. Although water power was relatively inexpensive in operation (once the costly dam and canal system had been constructed), it had two major drawbacks: (1) granite finishing sheds had to be located next to a waterpower site where there might not be an available workforce or worker housing and which exposed the shed to potential flood damage, and (2) during periods of low rainfall, there might not be enough water to operate the granite-working machinery.

Millworks typically consisted of a main shaft driven by the power source and one or more back (or counter) shafts driven from the main shaft and located over the machines to be powered. A millworks had three primary functions: (1) distribution and division of power from the prime mover to multiple distributed machines, (2) changing rotational speed from that of the prime mover to that required by each machine, and (3) changing direction from that of the prime mover (e.g., vertical to horizontal, rotational to reciprocating) to that required by each machine. Shafting was normally hung from the ceiling so that the moving shafts and belts would be out of the way of the workers. Power was most often transmitted between power source, shafting and machines by wooden or metal pulleys and flat leather belts. By altering the ratio of pulley diameters on each end of a belt, the rotational speed of the driven shaft could be increased or decreased. Power could be applied (or not) to a machine by shifting its belt from an idler (loose) pulley to a keyed (fixed) pulley (or vice versa), or by engaging (or disengaging) a belt tightener. For machines that needed to operate at multiple speeds such as granite cutting lathes (a slower speed was used for the initial rough turning), a system of speed reducing gears or a pair of cone (stepped) pulleys was employed.

By the time inland granite companies began to expand (1880s and 1890s), steam engines were readily available but their additional cost of purchase, operation and maintenance induced many companies to delay their introduction and continued to depend on water power. With the use of the steam engine, the drawbacks of water power could be avoided. The steam engine could be located almost anywhere, could be designed with a range of output capacities, and was not dependent on stream flow. However, compared to the water wheel, the steam engine cost more, had to be shipped at added cost from a distant manufacturer, had to be continuously attended and maintained, and was more costly to repair. In addition, there was increased insurance cost due to the risk of boiler explosions and fire. These negatives, added to the fact that small steam engines were not fuel-efficient, meant that steam engines were mostly installed by large granite firms. In 1909, Jones Brothers, one of the largest granite firms in Barre,VT, was powered by both water power and by a 150 HP Corliss steam engine. By 1913, Jones Bros. had a total capacity of 300 HP of mechanical power from both water and steam. Later, the Jones Bros. wheelhouse contained two cast iron horizontal wheel water turbines – each with a ten-foot vertical shaft connected by bevel gears to an electric generator. There was a clutch for each turbine that connected the turbine to the generator. Either one or both turbines could be connected, depending on the power requirements and available water. By the 1930s, the machinery at Jones Bros. was powered by electricity from the local electric utility (Green Mountain Power Co.). Two coal-burning Babcock & Wilcox steam boilers were used for heating only.

Often, the steam engine was just substituted for the water wheel or water turbine, retaining some or all of the overhead shafting and pulleys, belts, and gears. Or, the water wheel or turbine might be retained to provide low-cost power and the steam engine used as backup or to meet peak loads. Initially, wood-burning steam boilers were used, supplied with fuel from local woodlots. As coal became available and as local wood became scarce and more expensive (ca. 1880s), boilers were converted to burn coal. Also, coal allowed the use of mechanical stokers to replace the hand shoveling of coal into the boilers. For large installations, a coal trestle might be constructed for efficient railroad delivery of coal. An important byproduct of the boiler was the use of steam to heat the sheds during winter operations. Often, the exhaust steam from a steam engine or steam turbine was run through pipes in a heat exchanger. A fan blew air over the hot pipes and into large diameter ducts for distribution of hot air throughout the granite shed.

Just as water wheels were replaced by water turbines, reciprocating piston steam engines were replaced by steam turbines where greater power and rotational speed were needed such as for air compressors and electric generators (Fig. 3). Turbines are best used for applications requiring high rotational speed and continuous operation. Compared to the steam engine, the steam turbine is simpler, having only one moving part. In addition, the steam turbine has lower size and lower weight per horse power, higher efficiency (for large sizes), and can run for months unattended.

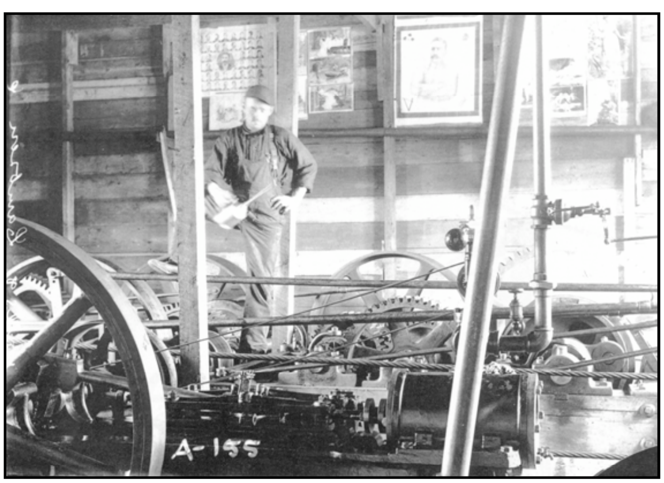


Figure 5. *Steam Piston-Powered Derrick Hoist, Barre, VT.*

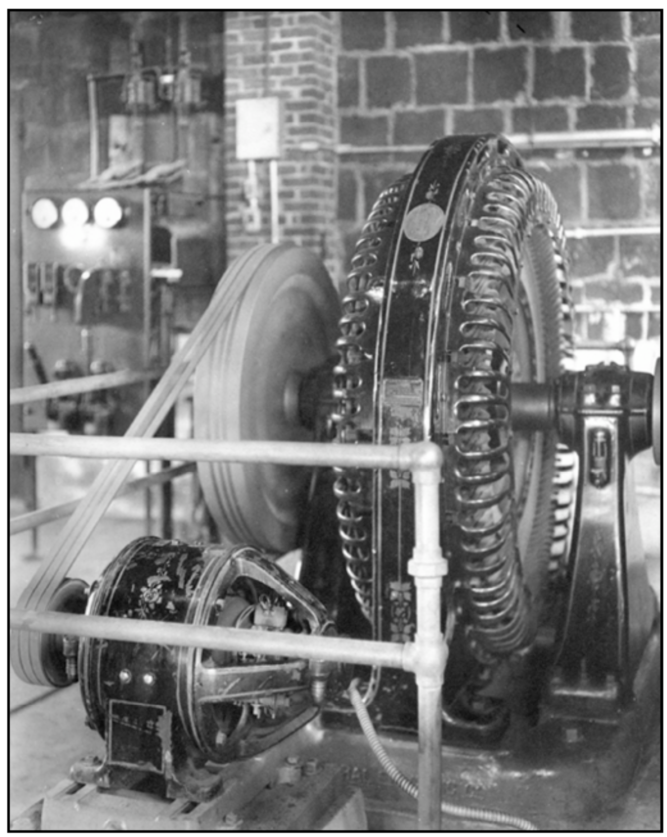


Figure 6. *Electric Motor Drive for Air Compressor. (The small motor is a starter motor.) Jones Bros., Barre, VT.*

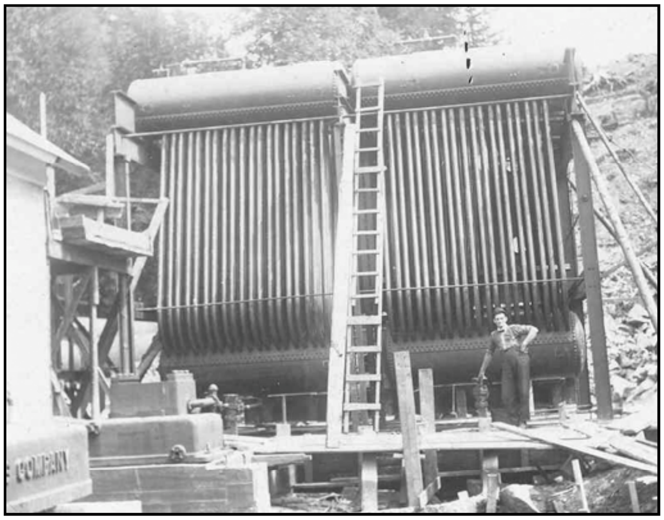


Figure 7. *Babcock & Wilcox 1000 HP Vertical Steam Boiler, Woodbury Granite Co., Hardwick, VT.*

The mobility of the steam engine made possible the low-cost transport of granite via railroad and opened up the interior granite quarries for exploitation. Before this time only the coastal quarries, serviced by sloops and schooners, could be profitably operated. Overland transport by horses and oxen was both slow and expensive. Really heavy loads (50 tons) might require a team of two or three dozen oxen and horses and might proceed at the snail-like pace of one or two miles per week! In addition, the heavy granite loads caused deep ruts in the dirt roads and crushed the culverts running under them, much to the anger of local residents. Initially, locomotives were wood fired but by the 1880s were being rapidly converted to coal. Coal weighed half or less and had a volume several times less than seasoned hardwood of the same heating value. By carrying their own fuel, wood or coal in tenders, locomotives were not tethered to a stationary power source. Although by the 1870s interior New England was well serviced by rail, it was not until quarry railroads, with their steep grades and sharp curves, were built in the 1880s and 1890s to haul granite from the quarries to the finishing sheds that the interior New England granite companies really began to prosper. Strong-traction saddletank locomotives were often used on quarry railroads and, for extreme grades, geared locomotives on which all the wheels were driven were used to provide outstanding tractive power for grades of 10% and more (Fig. 4).

Quarries posed special problems with respect to power. Quarries were often located at higher elevations with no rivers or streams for water power. By the 1870s and 1880s, coal was often transported to the quarry by wagon to fire boilers which provided steam for drills and derrick hoists (Fig. 5). Later, if the quarry was serviced by a railroad, coal might be brought in very economically. Sometimes water was so scarce that it was a challenge even to find enough to replace the steam engine's escaped steam and for wet drilling (the use of water to remove granite cuttings from the drill hole and to keep down the dust). Although the high and exposed location of many quarries suggests the possibility of using wind power, the author is not aware of this source having been used in the granite industry. The only significant New England use of wind power appears to have been on waterpower-poor Cape Cod for the salt industry and for grist milling. In any case, even the largest windmills of that time produced only three to five horsepower, far less than the power needed for the typical granite operation.

As mentioned above, steam was initially (ca. 1870s and 1880s) used to power quarry drills and derrick hoists. Steam was difficult to handle and always dangerous. After the 1880s, compressed air gradually replaced steam. Pneumatic rock drilling was pioneered in the U.S. in 1866 at the Hoosac Tunnel in western MA, powered by air compressors directly connected to water turbines. When compressed air began to be used in the granite industry in the late 1800s, first steam turbines and then electric motors were used to drive air compressors. Compressed air has many advantages: there is an inexhaustible supply of air and air exhaust is no problem, pipe leaks are not as dangerous, compressed air can be transmitted several miles without significant loss, it can be easily subdivided for use by many tools and machines, and can be used expansively in unmodified steam engines or in a variety of specialized air motors. The one major drawback was air compressor inefficiency (only 40-55% in the 1890s) due to heat loss during compression. However, the convenience of compressed air more than compensated for this inefficiency. Air compressors require relatively high torque and rotational speed which could be delivered by steam turbines. Electric motors did an even better job of driving air compressors (Fig. 6). The use of compressed air deep hole quarry drills, plug drills, jackhammers, and derrick hoists as well as surfacing machines (to produce flat granite surfaces) and hand-held pneumatic carving tools in the finishing sheds did not really become widespread until the advent of the electric motor-driven air compressor in the 1890s.

The next major step in power technology was the introduction of electrical power in the 1890s. Initially granite sheds produced their own electric power by water or steam turbine-powered generators. In 1909, The Woodbury Granite Co. of Hardwick,VT, the largest building (construction) granite company in the U.S., had their own proprietary electric power plant with two hydrogenerators producing a total of 500 KW (373 HP). By 1913, the Woodbury Granite Co. power plant could generate 1000 HP of hydro power and 2000 HP of backup steam power. The Woodbury Granite Co. fired the steam boilers with sawdust and waste slabs from it's sawmill whenever possible and only burned the more expensive coal when the scrap wood was not available (Fig. 7). Later, in the early 20th century, public electric power utilities increasingly supplied power to the sheds. At first, a single large electric motor would be used to replace the steam engine or turbine, using existing millworks. As smaller, lower-cost motors became available, multiple motors were used, each powering a group of similar co-located granite-working

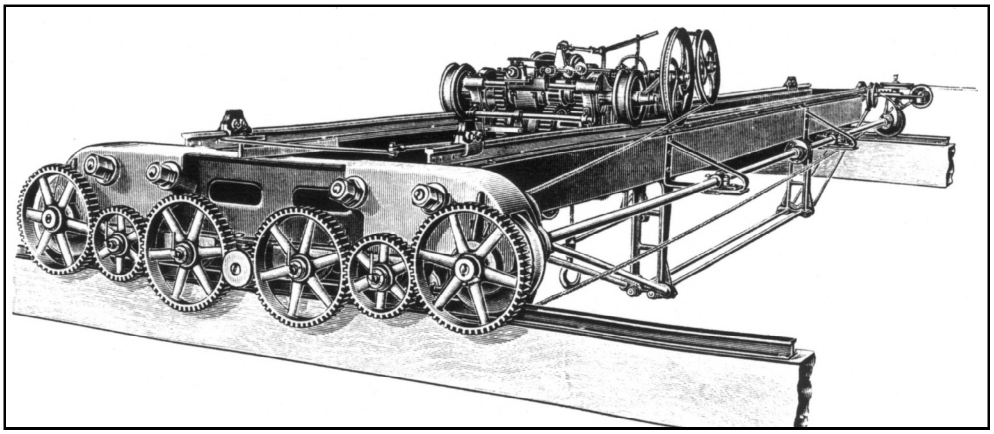


Figure 8. *Rope-Driven Overhead Traveling Bridge Crane, Manufactured by Lane Mfg. Co., Montpelier, VT*

machines. Finally, each machine was manufactured with its own integral electric motor. The use of one motor per machine greatly simplified power transmission from motor to machine (usually a geared or direct connection) and meant that the motor needed to be running only when the machine was in operation. Also, a machine with an integral motor could be more easily moved. Finally, and perhaps most important, the mechanical millworks which consumed from 20% to 50% of the power generated were replaced by electrical connections that consumed 5% or less of the power generated. As electric motors continued to decrease in size, the power per motor volume and weight increased and hand-held tools were developed with integral motors powered via an electric cord. (An early pre-electric example of a machine with a "built-in" motor was the tub wheel grist mill in which a horizontal water wheel with vertical shaft was directly connected to the upper mill stone.)

An important byproduct of the electric generator was the ability to use electric lighting. Centrally-generated electricity was originally introduced as power for the electric light with power for the electric motor as a byproduct. Much granite working required good light, for example for fine carving and sculpting, and electric light bulbs were able to provide improved lighting during late winter afternoons and cloudy days. A typical installation was a row of 500 watt light bulbs with porcelain reflectors hung below the shed roof ridgeline at intervals of twelve feet or so.

Since the cost per horsepower decreases as the prime mover size and capacity increases, economy of scale drove the granite industry to build boiler houses with multiple large steam boilers (usually, due to fire hazard, a masonry building separate from the main shed), to build compressor rooms with multiple large air compressors, and finally to purchase electric power from public utilities. This both reduced the cost of power and improved reliability by the backup power generation capability of multiple prime movers. Often an entrepreneur would install a large air compressor and sell compressed air to surrounding small to medium-sized granite sheds that couldn't afford to buy a compressor. Or, an entrepreneur might build a granite shed with compressed air, electricity, heat and lighting and rent space to small granite firms. Sometimes, a small firm purchased surplus compressed air or electric power from a large neighboring firm.

At high voltages, electrical power can be transmitted over long distances without significant energy loss which makes region-wide electric utilities possible and allows the tapping of previously unexploited remote water-power sites by hydroelectric power. Steam and compressed air is more difficult to transport over long distances due to frictional and heat losses and therefore led to the use of localized boiler houses and compressor rooms. Transport of power mechanically, for example by hemp or manila rope, or by steel cable or rods, is even more limited, typically a mile or less. Steam and compressed air was transported to work sites or stations by large diameter (four inches) rigid threaded iron pipes. At each work site or station, a smaller diameter (one half to one and a half inches) flexible rubber hose tapped off the iron pipe (through a turn-off valve) to power a tool or machine. For compressed air systems, a small diameter (three-quarter inch) steam pipe was often run inside the larger diameter iron pipe to heat the air and decrease the relative humidity. If not heated, the temperature of the exhaust air from the tool would be so low that the tool's valves and ports would freeze up, especially during winter, disabling the tool.

Mention has been made above of moving and lifting granite in the quarry. Material handling in the finishing shed was an even more challenging problem – granite had to be moved expeditiously from one workstation to the next for the various finishing steps. The solution to this problem was the overhead traveling bridge crane which could reach any part of a rectangular-shaped building, called a "straight shed". A typical shed of a medium to large-size company was several hundred feet long and had one or two overhead cranes that were in constant motion supplying the needs of one to two hundred granite workers. The key difficulty was how to power a machine that was moving over an area forty feet wide and several hundred feet long. The first solution was the "flying rope" overhead crane which was powered by an endless loop of rope, driven by a steam engine or electric motor, which ran the length of the shed on pulleys (Fig. 8). The rope loop ran onto the crane which moved on tracks over the length of the shed. The rope powered the movement of the bridge over the length of the shed, the movement of the trolley over the length of the bridge, and the movement of the hoist drum that was located on the trolley. There were two difficulties with this design: (1) the mechanism to translate the power of the moving rope to the motion of the bridge, trolley and hoist was complex and required frequent costly repairs and (2) the long loop of 1 to 1_-inch diameter rope moving at high speeds was dangerous – inone case having come off its pulleys and decapitated a worker. (Another example of a rope-powered machine for moving granite, in this case using wire rope, was the cable-way or Blondin used in the quarries to move waste granite and small granite blocks.) The best solution to powering the overhead traveling crane came with the availability of the smaller lower-cost electric motor. Three motors were used, one on the bridge to power bridge movement and two on the trolley to power trolley and hoist movement. Electric power was conveyed to the motors via conducting wheels that ran on bare copper wires strung the length of the shed and the length of the crane bridge.

Later in the 20th century, the internal combustion engine (diesel) began to power both electric generators and air compressors, especially at the quarry where, due to its remoteness, central electric service was often not readily available. In modern quarries, the diesel engine also powers large forklift trucks and long-haul flatbed trucks. The Fletcher Quarry in Woodbury, Vermont's highest producing quarry, consumes 40,000 gallons of diesel fuel per year. Although a small gas engine with gas tank can be designed integral with a tool (like a chain saw or lawn string trimmer), the author is not aware of any such tools for the granite industry – probably since gas engine-powered electric generators or air compressors can readily provide electricity or compressed air for electric or pneumatic tools at the working site. Since most granite-working tools require lots of power, a self-contained fuel supply is not really a good option and the tools must therefore be tethered to their power source to insure an adequate flow of power to the tool.

For the purposes of this article, a **tool** is defined as a hand-held and hand-guided unit designed to carry out a particular granite-working task. A tool may be human-powered or may be powered by steam, compressed air, or electricity via a steam hose, compressed air hose, or electric cable with, respectively, an integral steam engine (usually a small piston steam engine), compressed air engine (usually a small piston air engine) or electric motor. Although power can be supplied to hand-held tools via flexible shafting or belt arrangements, steam, compressed air and electric power connections are more flexible and allow the operator to more easily hold, move and guide the tool to perform its intended work. In fact, one of the key problems of tool design for granite working is the application of non-human power under the fine motor control of a human operator. Electrical connections are probably the most desirable, being flexible and lightweight, having low power transmission loss, and being simple to connect, for example by a plug. Steam and air hoses must be heavy and strong enough to withstand high pressure, heat, and moisture.

A **machine** is defined as a non-hand-held unit designed to carry out a particular granite-working task. A machine may be human powered but is normally powered through mechanical power transmission from an animal, water wheel/turbine or steam engine, or (as with a tool) by an integral engine/motor powered by steam, compressed air or electricity. A machine may be fixed (for example, bolted down), moveable (for example, on tracks), or portable (for example, on wheels). A stone may either be brought to the machine (for example, a gang saw, a very large twelve-foot by forty-foot machine which is bolted down) or the machine may be brought to the stone (for example, a pneumatic surfacer, a much smaller machine typically mounted on wheels). For most granite-working machines, the stone remains static while the machine's working head moves. One exception is the lathe where both the stone and the working head (cutting disc) move. A machine may require continuous human guidance (for example, a polisher in which the polishing wheel is continuously moved by hand over the granite surface), may be semi-automatic requiring periodic adjustments (for example, a quarry drill for which ever longer drill bits have to be employed as the drill hole deepens), or may be fully-automatic where instructions are issued via mechanical adjustments or settings, buttons, switches or keyboard after which the machine can complete a job unattended (for example, a gang saw for which the stone is positioned, the number and spacing of the saw blades set, and then the saw left to run with an abrasive slurry continuously delivered by a pump until the saw block is sawn through).

Since granite-working tools and machines work on granite mechanically (drill, split, break, saw, trim, hammer, carve, polish, grind, turn, sand blast, and crush), power has to be eventually translated into mechanical motion – driving steel or abrasives against the granite. (An exception is the flame channeler in which a high-temperature oil-oxygen flame spalls off chips by causing rapid temperature changes in the granite. The flame channeler is a complex machine, requiring inputs of oil, oxygen, water, electricity, and compressed air.) A water wheel or a water or steam turbine drives a shaft in a rotary motion which can be converted, if necessary, to a linear motion (for example, for a gang saw) by placing a crank on the shaft which drives the machine via a pitman rod. A steam, compressed air or gasoline-driven piston moves in a linear trajectory which can be converted, if necessary, to a rotary motion (for example, for a derrick hoist drum) by causing the piston rod to drive the machine via a shaft with a crank. If power is transmitted by compressed air or electricity, two additional steps are required between the prime mover and the final mechanical motion for granite working – power converter and secondary mover. For compressed air transmission, mechanical power needs to be converted to compressed air power by an air compressor and then converted back to mechanical power by an air motor. For electrical transmission, mechanical power needs to be converted to electrical power by an electric generator and then converted back to mechanical power by an electric motor.

Table 1 summarizes the power sources, prime movers, power converters, power transmission, and secondary movers for tools and machinery used in the granite industry. The power sources are shown in rough time order (from top to bottom) of utilization. The transmission of power is in four forms: mechanical (M), steam (S), compressed air (A), and electricity (E). Certain forms of power such a windmill prime movers, power transmission by hydraulic pressure, and tools with integral internal combustion engines have not been included since they were not commonly used in the granite industry.

Table 1 lists examples of tools and machines of the granite industry and shows how they fit into Table 1. Power Source 1 is man. Power Source 2 is draft animals. Power Source 3 is water wheel/turbine, steam engine/turbine or electric motor external to and mechanically coupled to the tool or machine. Power Source 4 is steam, compressed air or electricity used to power a steam engine/turbine, compressed air engine/turbine or electric motor integral with the tool or machine. Those tools or machines with Power Sources 3 or 4 but not Power Source 1 are automatic or semi-automatic – that is, do not require the continuous guidance and control of a human operator. The very important derrick hoist, used for heavy lifting both at the quarry and in the shed yard, is unusual among machines used in the granite industry since over time, it has been powered manually, by draft animals, by steam, by compressed air, and finally by electricity. Channeling, the cutting of a deep groove or channel around a block to be removed from the quarry, is a process that also has evolved through a number of technologies: steam quarry drill with broaching bit, channeling machine with an array of steam-powered chisels, pneumatic quarry drill with broaching bit, wire saw, pneumatic core drill, high-temperature flame channeler, and high-pressure water channeler.

One machine that is not represented by Table 1 is the early steam-driven, track-mounted channeling machine with an integral steam boiler that powered an array of chisels. This large and cumbersome machine was rapidly supplanted by a machine with an external boiler and a steam hose connection. I am not aware of any granite-working tools or machines with integral water turbine and pressure water hose connection or with an integral gas engine and integral gas tank or gas hose connection. There may have been experimental or small production examples of these but if so they never gained popularity in the granite industry. The high pressure water channeler and Hydrosplitter have integral electric motor driven water and oil pumps, respectively. In the former, the stream of high pressure water acts as an abrasive to wear away the granite. In the latter, hydraulic cylinders drive a knife at high pressure against a granite block, splitting the block along the knife edge.

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Table 1. Power Sources for Selected Tools and Machines

Tool (T) or Machine (M)	**Power Source**			
	1	**2**	**3**	**4**
Drilling Hammer (T)	X			
Hand Drill (T)	X			
Wedge & Shims (T)	X			
Striking Hammer (T)	X			
Bull Set (T)	X			
Hand Hammer (T)	X			
Hand Chisel (T)	X			
Stone Jack (M)	X			
Polishing Machine (Manual) (M)	X			
Derrick Hoist (Manual) (M)	X			
Ox Shovel/Scraper (M)	X	X		
Wagon (M)	X	X		
Sled (M)	X	X		
Derrick Hoist (Draft Animal) (M)	X	X		
Polishing Machine (M)	X		X	
Gang Saw (M)			X	
Lathe (M)			X	
Overhead Crane (Rope) (M)	X		X	
Wire Saw (M)			X	
Contour Wire Saw (M)	X		X	
Surfacing Machine (Mechanical) (M)	X		X	
Grinder (M)			X	
Sand Blast Machine (M)	X			A and E
Plug Drill (T)	X			A
Quarry Drill (M)				S or A
Derrick Hoist (M)	X			S, A or E
Pneumatic Carving Tool (T)	X			A
Surfacing Machine (Pneumatic) (M)	X			A
Overhead Crane (Electric) (M)	X			E
Polisher (Hand-held) (T)	X			E
Water Pump (M)				S
Grinder (Hand-held) (T)	X			E
Engraving Tool (T)	X			E
Water Channeler (M)				E
Hydrosplitter (M)				E
Flame Channeler (M)	X			A and E

GRAPHITE PRODUCTS CORPORATION

Graphite Mining/Processing Operation

Wilton/Greenfield, New York

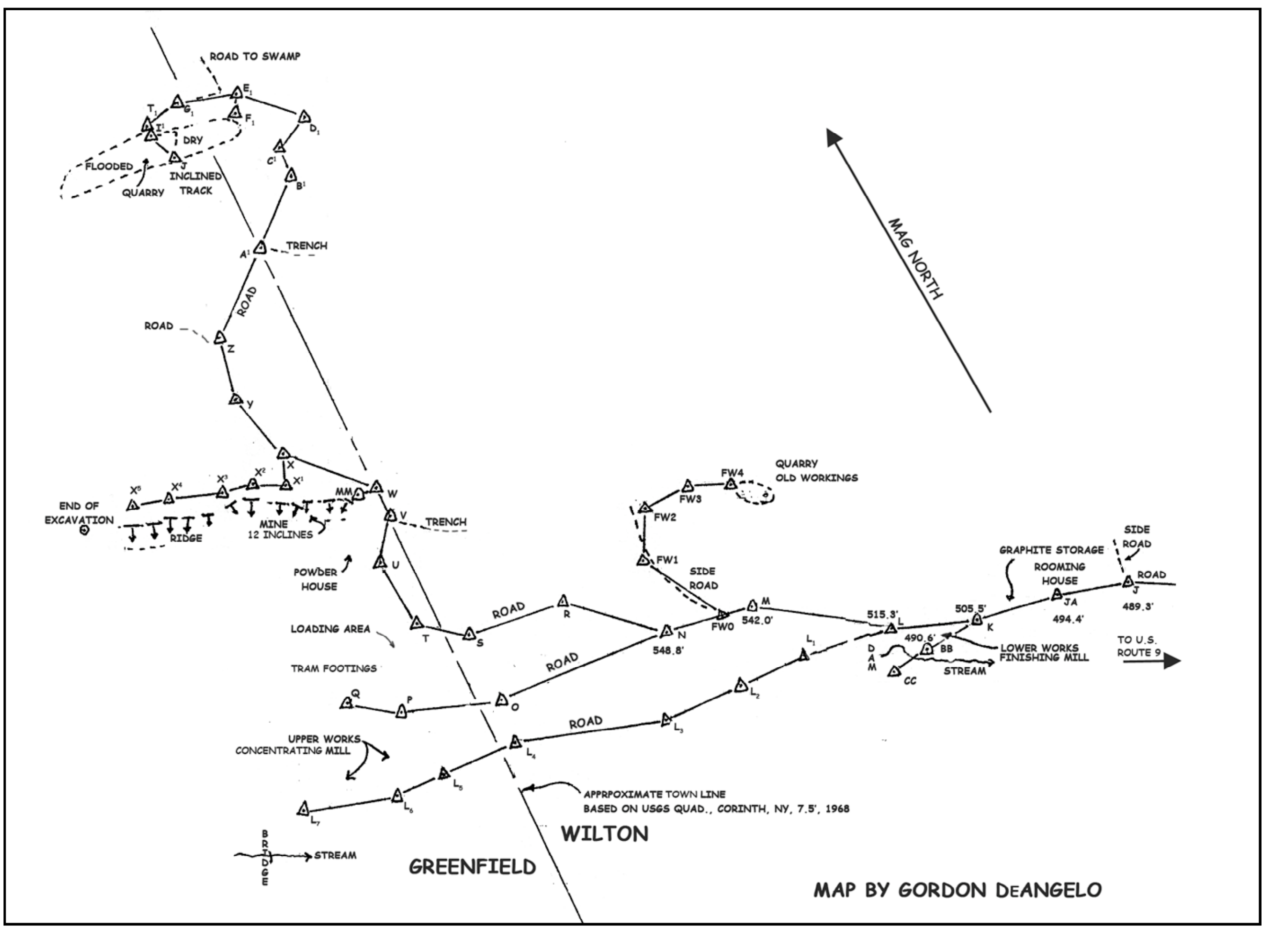
Of the four most productive graphite mines within the Adirondack Region, little documentation remains detailing the former operations at the Graphite Products Corporation in Wilton and Greenfield. A search of industry records, census data, and oral history reveals few clues about the workers who manned the year-round operation. However, the site itself remains virtually undisturbed except for natural processes of decline.

Graphite Mining in the Adirondack Region

The first commercial attempt to extract graphite from the Adirondacks occurred on Lead Hill near Ticonderoga in Essex County. In the 1850s the American Graphite Company operated the works there, and in the 1880s the Joseph Dixon Crucible Company took over the operation and became the first enterprise to import and manufacture graphite products in this country. Around 1902 the area began to attract attention, and in the following years many prospects were opened, companies formed and mills built for treating the ore (Alling 1917).

New York State soon became prominent in the production of high-grade graphite. Of these, the most productive were the American Graphite Company in Ticonderoga (later known as the Dixon and Faxon), the Hooper Mines in Dresden near Whitehall, Graphite Products Corporation north of Saratoga Springs, and Empire Graphite at Porters Corners (Alling 1917).

By the mid-19th century, many new uses came with the Industrial Revolution. The most important was the manufacture of crucibles used in the production of crucible steels, brass and other new alloys. Other uses included foundry facings that aided in the parting of cooled metal castings from their molds. Large amounts were used in stove polish, utilizing the small-sized or intermediate grades. As graphite



One of twelve drifts (mine openings). Photographed by Suzette Usher.

adheres to metal surfaces, it fills the pores and provides protective properties, reducing friction and acting as a lubricant. In a dry application, such as in textile mills where oil would soil the cloth, or for automobiles as lubricating oils and greases (Gwinn, 1943:13). Other uses included dry cell batteries, dynamo brushes, electrodes, steam and water packings, brake linings, and fertilizers. The paint industry made use of the lowest grade of ore, 30-35% purity; with manufacturers of crucibles, pencils and lubricants, 83-97% purity; and electrical component manufacturers consuming the material 97% or higher (Harrison 1955: 2-3).

Corporate History

In 1908 William A Pierson, attorney, William J. Delaney, attorney and Ralph H. Davison of Saratoga Springs with George F. Bryant and John H. Davis of Glens Falls, New York formed the Saratoga Graphite Company (SGC) with a capital stock of $175,000 (Papers of Incorporation Albany N.Y. 3/32/1908: 198-199). John H. Davis is listed as manager of the company from 1909 to 1910 (Glens Falls Directory 1909-1910). The mining and production of flake graphite was carried out in a minor way using open pit mining with all processing contained in one building until 1913 when John L. Henning from Saratoga Springs, Ralph H. Davison and William H. Namack of Ballston Spa, New York assumed ownership under the name Graphite Products Corporation (GPC). Graphite Products started quarrying ore in a new, much larger pit, abandoning the Saratoga Graphite Company's smaller open pit. A new multi-story concentrating mill was constructed and the former SGC building used as the refinishing mill. Davison and Namack also owned a nearby foundry.

Geology

The uplifting of the McGregor fault-line scarp, produced by differential erosion, forms the western boundary of the Lake George Depression and the Palmertown Range. GPC is located at the foothills of this range. The commercial deposits of graphite are found within the Grenville series; these are sedimentary rocks which are folded, metamorphosed and at times invaded by igneous rock. The metamorphosed rocks were subjected to heat and pressure resulting in the recrystallization or the rearrangement of the component minerals. In "The Adirondack Graphite Deposits" monograph, Alling provides detailed descriptions of the twenty-six deposits in the Eastern Adirondacks and divides these into the Northern (limestone and contact deposits) and Southern (bedded or blanket form of ore body) properties. These deposits were located from north at Lake Champlain south to Saratoga County, thus GPC is part of the southern area.

Graphite occurs in both crystalline and amorphous forms. The amorphous form is also crystalline but very fine grained. The crystalline variety is further categorized as flake, lump, chip, or dust. In New York State most of the graphite mined was of flake type and was classified by the size of the flakes, carbon content and impurities. Flakes more than 3 mm in diameter were rare.

The resulting graphite deposits were restricted to a stratum of quartzite or quartz schist ranging from 3 to 30 feet in thickness. These beds are traceable from Lake Champlain west to Johnsburg and from the Town of Hague, both in Warren County, south to Saratoga County. The graphitic rock does not exist as a continuous belt but in isolated patches that at one time probably did form a continuous bed. The rock has been folded and injected with various igneous rocks and faulted and dissected so that the deposits are irregular (Newland 1921).

At Graphite Products Corporation the graphite existed as a quartz–schist containing from 7.7 to 7.9% graphite, 73% quartz and trace amounts of biotite, mica, feldspar, serpentine, pyrite and apatite. There were two sets of workings, the quarry and the open pit. The deposits range in depth from 15 to 20 feet and are cut by several vertical faults.

Site Location

Graphite Products Corporation consists of the remains of the graphite mines and associated mill complex. The site is located about four miles north of Saratoga Springs, New York, in the Towns of Wilton and Greenfield, west of NYS Route 9. The property on which the GPC complex was built included 31 acres in the Town of Wilton and 118 acres in the Town of Greenfield. The construct of the site is essentially linear, connected by a dirt haul road formerly used for the mining and

Concentrating mill remains. Photographed by Suzette Usher.

industrial processes and existing today as a walking/logging trail connecting the contributing elements within the site. The elevation from the highway to the quarry rises from 343 to 649 feet above sea level.

Site Description/Process Flow

The following describes the extant physical features of the former GPC mining and industrial complex on the property. The order of the features mirror the mining and processing activities conducted on the site during operation. The locations of the activities reflect both the landscape and topography of the property: the mining areas are located at the highest elevations, transport by rail utilizes gravity, and the waterpower to the processing buildings exploits the down slope forces of the stream.

The main portion of the dirt haul road runs from U.S. Route 9 to the quarry. The road branches off above the dam and leads to the bottom of the concentrating, mill. To the southeast of the mine openings another branch leads to the top of the concentrating mill.

The Graphite Products mine and mill complex includes two bodies of water: one is an unnamed stream running east from the Town of Greenfield to U.S. Route 9 where it flows under the road continuing to Lake Elizabeth; and the other is the man-made quarry at the farthest northwest portion of the site which is now partially filled with water.

The quarry or open-pit mine is located in the northwestern portion of the site approximately 4300 feet from U.S. Route 9. The quarry runs east/west and measures 200 feet in length, 20 to 80 feet in width and 30 feet in depth. The western portion is now filled with water. The ore was hauled from the east side of the quarry by an inclined track using a small auxiliary or "donkey" engine and dumped into wagons for transport to the concentrating mill. At 200 feet to the southeast the road crosses a shallow trench. The first few feet are loosely lined with rock, and remains of what appears to be a later rail line are visible approximately 20 feet from the road crossing. Following the road 400 feet to the south are the openings to the mine. This area consists of an open pit 375 feet long with 12 inclines or non-vertical shafts (average height from 13-24 feet; average width 8 to 39 feet). These inclines were driven on a slope down to meet two horizontal drifts following the graphite body. These subsurface workings are now filled with water. Mill tracks were laid within.

To the north and parallel to the mine openings are the remains of the waste rock extracted from excavating the openings. From the eastern end of the mine the rail cars exited. Behind the mine openings on the southern side is located what may have been the powder house, comprised of a single layer of heavy stone 11 feet square with an opening (doorway) facing southwest. At approximately 200 feet to the south is a large level area measuring 40 by 60 feet supported on two sides by a heavy stone wall. This is the loading area. From this location there are two parallel rows of four each square stone/concrete footings, each measuring approximately 3 feet square by 2 feet in height. These appear to be the remains of the stone supports for the tram that delivered the ore from the mine to the concentrating mill. As in other mining complexes, the process made use of gravity by constructing the mill on the hillside.

The multi-level foundation made of stone and concrete measures 51 by 94 feet in diameter. Within the foundation are the remains of many concrete footings or supports for machinery and line shafting. To the east was a smaller addition measuring 32 by 39 feet possibly for stamp milling or the powerhouse. Attached to this was a smaller room 20 by 20 feet square made of rough laid stone. The mill water was supplied by a stream flowing past the mill to the south. The brook valley was dammed and received the tailings. The water was filtered through sand banks and reused (Alling 1917). The dam is located 1000 feet to the east of the mill and is constructed of earth, rock and wood. To the northwest approximately 300 feet is the site of the former SGC quarry. This pit measures 75 feet east-west by 30 feet north-south, worked by Saratoga Graphite Company. To the east of the dam is the GPC finishing mill previously used by Saratoga Graphite Company as a concentrating mill.

This is a two-level foundation made of stone and concrete. A massive stone wall rises 10.5 feet from the stream bed and supports the lower level which measures 72.5 by 32.5 feet. The remains of several quartzite millstones are present. A concrete/stone wall showing wood impressions rises 7.5 feet to the upper level. A series of 12 threaded pins protrude from the wall evenly spaced near the top and below at floor level. To the east is another area measuring 35 by 14.5 feet and a still smaller foundation in the front measuring 7 by 6.5 feet. The walls here are in poor condition. The largest area on the upper level measures 54 by 14 feet. This area contains the partial concrete, stone and wood remains of what appears to be a steam engine mounting with a flywheel pit possibly used for line shaft belting overhead to operate processing equipment on the floor below. Adjacent to this are the remains of what appears to be a graphite storage bin. It is possible that a drying kiln, boiler room chimney or furnace may have been located on this same level, as the remains of refractory type brick are scattered about. An earth and riprap wall 5 feet high supports the road above.

Across from the finishing mill are the remains of the storage/loading area. In this area the graphite was sorted and stacked by grade, ready for shipment by horse and wagon and later by truck down to Route 9 and the trolley to Saratoga Springs (Petteys 1998). Different grades of graphite and the partial remains of wooden pallets and asphalt shingles were recovered here. Adjacent to this are the remains of the rooming house. The foundation consists of a small concrete boiler room and a larger cellar hole. Window glass, asphalt, brick, coal, ash, chimney tile, lamp glass, ceramics, broken bottles and cutlery were found to the rear of the foundation. The road continues east down to US Route 9.

Concentration Process of Flake Graphite

The greatest problem facing the graphite mine owners of the Adirondacks was the separation of the flake graphite from its associated gangue minerals without destroying the flakes or unduly reducing them in size. This is difficult as crushing forces small grains of gangue into the graphite. The process calls for long experience and mechanical ingenuity. Numerous failures were attributed to the separation process. In addition, the character of the ore could change as mining operations proceeded. This separation process is divided into two stages: “concentration” and “refining.” Most commonly the concentration was performed at the mine site and the refining at another location. GPC was one of only three mines in the southern Adirondack area (the others being the American Graphite Company in Hague and the Flake Graphite Company in Porters Corners) that carried out both separation stages at the mining location (Alling 1917). The separation of ore from gangue was based on the distinctive physical and chemical characteristics of each. Some of these characteristics are differences in specific gravity, electrical conductivity, selective behavior of a mixture of water and oil upon the surface tension or upon the magnetic properties of the ore and gangue material. As a result of the separation process, the lighter graphite material was saved and the non-

Buddle components at concentrating mill. Photographed by Suzette Usher.

usable gangue was discarded.

The specific gravity method of ore concentration is subdivided into the wet and dry process. Both methods require that the ore, as it comes from the mine, be reduced to a pulverized condition. This was achieved by the use of crushers and stamps. The crushers reduced the ore to one and one half to three-inch pieces. From the crushers, the ore was sent to the stamps. A stamp is a heavy cam pestle that is raised in a huge iron mortar by steam or other power working; when dropped, the stamp or pestle creates a finely crushed ore. There were 3 banks of 5 stamps each in operation at GPC in 1918 (Clark 1918). GPC used the wet process, as did most of the other Adirondack mines. In this process the crushed rock is mixed with water and fed to a series of buddles. Buddles are circular tanks three and a half to four feet in depth and 16-18 feet in diameter. The buddle has a slightly convex bottom so the floor of the tank slopes in all directions from the center to the outside. A vertical shaft in the center carries a tub up to three feet in diameter with a perforated bottom.

The mixture of water and ore is fed into the tub by a stationary sluiceway or launder. The ore enters the buddle at the center and is carried to the sides by the water that escapes through specially arranged openings. This process was controlled either by manually operated valves or wooden stoppers. The actions of paddles or brushes that are attached to two horizontal arms secured to the center shift assure the even movement and distribution of the layers of slime. These revolving brushes or paddles lightly rub the surface of the material and gradually slide up the center shaft as the buddle is filled. The graphite flakes, due to their low specific gravity and flaky, scaly nature, are mainly floated to the sides, and the heavier minerals drop near the center of the tank. It could take several hours to fill a buddle so usually a series of them were used; while one was filling, another was emptied. After the tank was filled with the materials, it was allowed to partially dry and was shoveled up. An account written by Wilford C. Ross (1976: 19) about the graphite mine in Hague mentions "…. shoveling buddles was hard labor. Men received about five cents per hour. At times finishing in six hours...conditions in the mill were so dusty that it was hard to identify a fellow worker."

The outer portion nearest the wall of the tank was usually clean. The inner portion consisting of sand tailings was not used, and the middle portion containing both graphite and gangue material was passed to the next buddle for further concentration. Two to three buddles usually made up one set and the same number made up a second set. The buddle concentrate was further treated using revolving screen wheels. These were hexagonal and covered with screens of various mesh sizes. The reels were inclined slightly; the ore fed into one end, and the concentrates were thrown out the other end as the reels rotated. Jets of water directed against the outer part of the reel helped to separate the graphite and impurities that, because of their small size, passed through the screen and were discarded. The seconds are sometimes reground to remove the quartz and feldspar grains and sent through the screens again. The graphite was then dried by either direct or steam dryers.

In 1918 the Adirondack mines, including GPC, started substituting oil flotation for the buddle. The addition of oil to a combination of water and air separated the graphite from the gangue. This effected an increased saving of the graphite and reduced the amount of mica admixed with the product. The product was now ready for the refining mill (Newland 1919).

The Hooper pneumatic concentrator or air jig, manufactured at the Ticonderoga Machine Company, was the machine used in the final treatment of the graphite concentrates. This machine eliminated problems caused by the need for pumping large quantities of water and ore separation residues/waste in freezing weather; however, one disadvantage was its small capacity. Supposedly one man could tend six machines. Because the Hooper concentrator did not require the use of water, it enabled the company to work later in the season. The concentrator consisted of an inclined frame over which a broadcloth screen was stretched. A device below delivered a continuous series of air pulsations. Two sets of strips were placed over the cloth screen; the lower group inclined toward one side and the other inclined in the opposite direction "…and when (concentrates) composed of particles of different gravities are fed upon the (screen) the pulsations through the broadcloth…cause the heavier mineral particles to be thrown (settle) to the bottom…and are thus guided…toward the tailing side of the (concentrator)" (Alling 1917: 131). The clean graphite was guided by the upper set to the opposite, or concentrating side. This further separated the gangue and the ore. The presence of several quartzite broken mill or burrstones suggests that these stones may have been used to reprocess the waste rock to free additional flakes of graphite.

Decline

During 1916 and early 1917 the amount of imported graphite from Ceylon, Madagascar and Korea was about eight times the domestic production. Of this, 90% was used in crucible manufacture. Open pit mining requiring only cobbing or washing for milling, lower labor costs, and high grade deposits found on Ceylon and Madagascar made the importation of foreign graphite very economical. The use of these imports was unrestricted until 1917 when the US entered World War I. During the winter of 1917-18 with freight conditions congested, an embargo against shipment of domestic graphite was ordered. This remained in force until early March 1918. This caused a stagnation of the domestic mining industry. Even so, 1919 production stood at 3,266,518 pounds of graphite, the highest amount in its history (Hartnagel 1927). The removal of freight restrictions was followed in April by a complete embargo on imports until July of 1918. On July 2 the embargo was extended until the end of 1918. At that time the War Industries Board made the request that 20% domestic graphite be used in crucible manufacture, and in 1919 this was increased to 25%. The board also required that applications made for import licenses by manufacturers not complying with the provisions of the request, not be approved by the board.

Before the declaration of war in 1914, all crucible makers in the US used clay imported from Bavaria. Little work had been done on domestic or English clay and with the supplies being cut off during the war, the industry was forced to find alternative methods or supplies. This did not prove to be a serious obstacle; however, even in the course of experiments, no great success resulted in the use of more than 25% domestic flake graphite in crucible manufacture. It was hoped that the improvements in the brass and steel manufacturing production would be on a firmer basis than many small companies only producing crucible stock (Dubb 1920).

The mining of graphite in New York State, at one time one of the leading states in graphite production, came to a standstill in 1921. Although no production statistics are given for the last three years of mining, in 1919 the value of graphite produced in New York exceeded that of any other state. In 1920 New York's production was second only in the value of graphite sold, the other being Alabama, with only two mines in operation. In 1921 only one firm reported production. The suspension of graphite mining was simply due to the low price of the product. This seriously affected the industry throughout the United States. In 1918, 42 operations were reported and in 1923 only 7 (Hartnagel 1927: 42, 43). Low import prices made local milling costs prohibitive: 4 to 5 cents a pound, duty paid, compared with domestic prices from 14 to 18 cents per pound to produce. From 1937 to 1942 a deposit near Pope Mills, St. Lawrence County, N.Y., operated in a small way, but new explorations gave no indication of quantities needed to be profitable and by 1942 all operations ceased (Harrison 1955: XXII-5-6).

According to tax records, between 1915 and 1922 the GPC included 31 acres in the Town of Wilton and 118 acres in the Town of Greenfield. The owners paid taxes on the land, machinery and structures [buildings] to both towns (Saratoga Tax Records 1917-1922). Exactly when GPC stopped mining and processing graphite in Wilton is not known. The tax records include GPC until 1929, although the property values and listing of the mines, mill and machinery are no longer mentioned after 1920, the year of the highest taxes collected (Saratoga County Tax Records 1915-1924).

Final Thoughts

Research on this project started in the early 1990s when I made a wrong-turn while walking with a friend to see the frequented massive graphite mine openings. There on the side of the trail were two large, circular, metal objects. Behind these were the ruins of a large foundation. Little did I know that this was part of a large mining and milling complex, a part of the greater Adirondack graphite mining industry.

Ongoing research continues in hopes of promoting the history and preserving the site as part of our industrial archeological heritage.

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History of Camp Columbia

1885 to the present

1904 Recreation Building

Morris, Connecticut, located on Bantam Lake, approximately seven miles south of Litchfield, was a bustling resort community in the late 19th century. In 1885, a group of 46 students from the Columbia College School of Plane Surveying escaped the heat of New York City to spend their summer at an engineering camp in the country. They stayed the season at the Horatio Benton Farm, working and learning in the surrounding towns and forests. Between 1886 and 1891, groups of students returned every year, mostly living at an inn at the north end of Bantam Lake, named Island Hotel. Due to the popularity of the program, Columbia College (now Columbia University) decided to create a permanent outpost for the Engineering School. Camp Columbia was populated by students until the early 1980s. The 591-acre property was sold to the State of Connecticut Department of Environmental Protection in 2000.

In early 1891, Columbia University began the lease of 120 acres of land, south of Bantam Lake, from Emily Waugh. The parcel included a farmhouse, two barns, several farm support buildings, and large fields previously used for agriculture. Students who used the camp in the early years lived in thirty-five tents surrounding the main farmhouse.

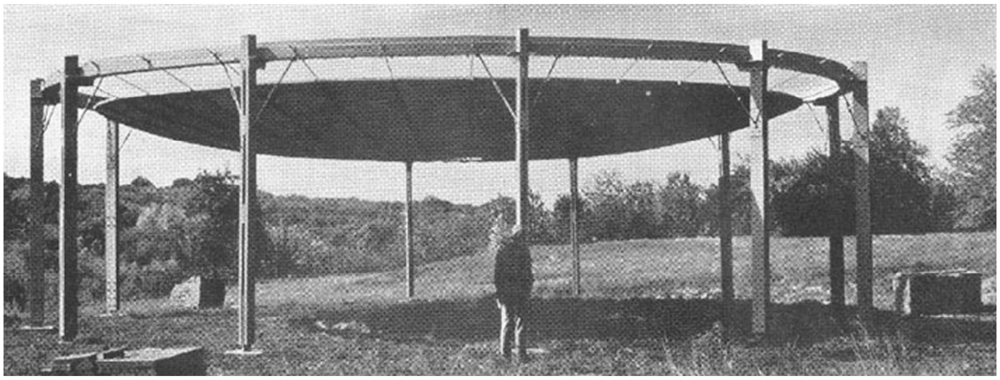
Camp attendance increased from 52 students in 1898 to 195 students in 1903. The University began to buy large tracts of land surrounding their tent city and to replace the tents with permanent buildings. Between 1903 and 1917, an additional 471 acres were added to the property, including a narrow access-way to the lakefront. Six new buildings were erected, including the North and South Dormitories in 1903, the recreation building in 1904, the administration building and stone instrument house in 1907, and the boat house in 1914.

The Engineering School had begun to teach summer classes in Pelhamville, New York, in 1884 and moved to Connecticut in 1885. The summer courses intended to teach students not only the skills of surveying, but also the value of teamwork and community living. Learning exercises included: contour sketching, chaining, farm survey, city survey, reading angles with a transit, and the survey of 80 to 90 acres on a scale of 1/1000. "The classes assembled each morning at a quarter to eight for a roll call and a lecture on surveying. The lecture lasted until about eight-thirty and was devoted to instructions for the day's work. The remainder of the day was spent in field work, either in classroom … or actual surveys." Other coursework offered at Camp Columbia included: plane surveying, railroad track location, and a hydrographic survey of Bantam Lake.

The Camp served its country as a military training facility for Columbia students who expected to participate in World War I. From 1917 to 1919 students received training in military drills, rifle practice, map making, and camouflage training. Over 300 yards of trenches were dug into the property to simulate the warfare conditions in Europe.

The now 591-acre Camp developed even further in the period between 1930 and 1950. On the 51st anniversary of the founding of the Camp, in 1935, a spacious fieldstone Dining Hall was built. As a gift from the Class of 1906 the existent wooden water tower was replaced with a stone tower in 1942.

1907 Administration Building



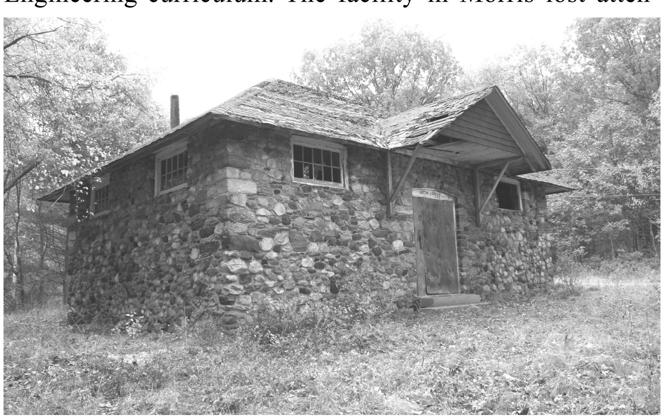
Funaro Dish (Above) *1942 Stone Tower* (right)

In 1948, Dwight D. Eisenhower became president of Columbia University. A great football enthusiast, he encouraged the creation of a miniature football field and sports program at Camp Columbia. Although no conclusive evidence has been discovered, local lore states that the New York Giants used this as a practice field at some point.

One of the more interesting building projects on the property was the 1956 Funaro Dish. Named for architect/designer Bruno Funaro, the pre-stressed concrete roofed open-air pavilion was a fifty-foot diameter "dish" with a fifteen-foot high, suspended saucer-shaped roof. The roof was supported entirely by thirty-six steel cables fanning out from a metal ring at the center to a laminated wood ring bolted to twelve columns. It is possible that this structure served as a small-scale model for the 1964 construction of Madison Square Garden in New York City.

By the 1950s attendance at summer classes at Camp Columbia were mandatory for students of the Engineering Department. Courses offered at the Camp during this time included: Chemical Engineering, Civil Engineering, and Technology & International Affairs. The Columbia University American Language Center held lessons for international students taking entrance exams to American colleges and universities.

The 1960s and 1970s saw a decline in interest in the "camp" environment and changes to the School of Engineering curriculum. The facility in Morris lost attendance dramatically. By the early 1980s, Columbia University decided to close the camp and attempt to sell the land. In 1989, the land still unsold, the Morris Fire Department declared that some of the buildings had fallen into such disrepair that they had become a public hazard. The Morris Fire Department used several buildings training structures in controlled fire management drills. In 2000, the State of Connecticut, Department of Environmental Protection, Division of State Parks and Public Outreach acquired the property and buildings through a Recreation and Natural Heritage Trust Fund Grant.



Stone Instrument Building

Archaeological investigation undertaken in 2002 by Turk, Tracey, & Larry Architects, LLC, revealed little evidence of precontact Native American activity. There are six known precontact sites within one mile of Camp Columbia, but no conclusive evidence of a settlement on the property. Several areas on the property have been set aside as possible precontact settlement sites. These locations were determined by comparing landscape features to those of other known precontact sites.

The property is currently under the stewardship of the State of Connecticut, Department of Environmental Protection, Division of State Parks & Public Outreach. It is their intention to preserve the land for open green and recreation space. The majority of the buildings on the property suffered from a lack of maintenance and upkeep and, for public safety reasons, must be razed, with the exception of the 1942 Water Tower, which will be preserved and restored. The Department of Environmental Protection hired Archaeological and Historical Services, Inc., a private consulting company, to do extensive photographic, historic, and archaeological documentation of the still-standing structures and property in total. Currently, work is being done on an interpretive trail system throughout the park to convey to the public the deep and interesting history of this fascinating piece of land.

Nicole Chalfant
State of Connecticut, Department of
Environmental Protection,
Division of State Parks & Public OutreachHoadley Pond Dam

Hoadley Pond Dam Repair Project, Seymour, Connecticut

Background and Objective
GZA GeoEnvironmental, Inc. of One Edgewater Drive, Norwood, Massachusetts, is providing dam repair and construction engineering services for the Aquarion Water Company of Connecticut (formerly the BHC Company). The purpose of the dam repair project is to repair observed deficiencies at the dam and update the dam to modern dam safety standards.

Scope of Project
The ongoing construction work involves the repair of the stone masonry and concrete dam structures and outlet works at Hoadley Pond Dam. No construction of new structures has taken or will take place other than those structures associated with the dam. The only structures impacted by the project are those associated with the dam (i.e., dam, spillway, and outlet works). The total acreage of the project area is less than 1 acre. The ongoing work involves the dewatering of portions of the upstream and downstream river channel, the repair of damaged and displaced portions of the dam, construction of concrete buttress structures to provide additional stability to the dam, and reconfiguration of the left abutment/forebay area to allow for increased spillway capacity needed to pass the design flood. Work at the dam began in February of 2008 and is scheduled to be completed by the fall of 2008.

Description of Dam and Appurtenant Structures
Hoadley Pond Dam is located on the Little River in Seymour, Connecticut. The dam is classified as a Small size, "Significant" hazard dam. The contributory watershed to the dam is approximately 14.6 square miles. The dam is located behind the Klarides Village commercial development, about 250 feet downstream of Bank Street. The original dam in this area was reportedly first built in the 18th century to accommodate mill operations, since breached and re-built at its current location. The dam is now owned by Aquarion and is no longer used for water supply or any other purpose by Aquarion.

Hoadley Pond Dam is a 19-foot-high, 145-foot-long mortared stone masonry dam with a 67-foot-long primary spillway. There are eight timber nappe breakers (vibration dampeners) strung across the spillway by a steel cable, which is wrapped around the right abutment and the outlet works control mechanism at the left of the dam. The spillway elevation is about 155.0 feet. The top of the dam elevation varies from 159.3 feet to 159.7 feet (NGVD). In addition to the primary spillway, the dam has a forebay with an auxiliary spillway at the left abutment. Flow into the forebay is controlled by a 5-foot-high by 7-foot-wide sluice gate, which can be operated from the top of the dam.

Flow through the sluice gate passes through a rectangular conduit and into the forebay area that is formed by stone masonry walls that are capped by concrete. The forebay has two controlled outlets: a) a 16-inch-diameter iron pipe which runs through the right masonry sidewall and b) a 24-inch-diameter corrugated metal pipe which conveys flow downstream and eventually to the Little River, about 60 feet downstream of the dam. The forebay also has two spillways: a) an 8-foot-long auxiliary spillway at elevation 155.0 feet (the approximate same elevation as the primary spillway) and b) a 12-foot-long auxiliary spillway at elevation 155.4 feet.

Based on previous visual inspection reports and GZA site visits over the past ten years, the condition of Hoadley Pond Dam is considered poor and continues to deteriorate. Deficiencies noted in recent visual inspections of the dam include displaced and/or missing stones at the right abutment and toe of the left forebay wall, a significant crack and displacement of stones above the forebay outlet structure, peeling of surficial concrete at the outlet structure, and deterioration of stone masonry mortar throughout the dam.

Site History
No original construction information or design drawings concerning Hoadley Pond Dam are available. The History Society of Seymour website, (http://electronicvalley.org/tour/hoadleyspond.htm), provides the following historical information about Hoadley Pond: "As you approach the end of West Street, and prepare to turn right onto Route 67 (Bank Street), you will notice to your left what is known as Hoadley's Pond. This pond, created by the Little River, which empties into the Naugatuck River, is a favorite place to ice skate during the cold winter months. During the late 1800s, Mr. Edward Hoadley used the water power from this river to operate a large and very successful saw mill business for 20 years. In 1898 the saw mill completely burned down and he decided not to rebuild. Mr. Hoadley was a well respected citizen of the town and served as selectman for 4 years."

Between the late 1890s and the mid-1900s, little is known about the dam. Records from 1964 of the sale of the dam and surrounding property show that the land had been owned by the Housatonic Lumber Company of Derby, Connecticut, and indicate that the dam was used to provide water power for the adjacent mill. The dam and surrounding property was sold to the Seymour Water Company of Seymour, Connecticut, on February 24, 1964. According to the 1964 Map of Land, water from the dam was diverted to the downstream mill building via the forebay "raceway." The dam itself is identified on the Map as the "penstock wall." The forebay auxiliary spillway was also in active use at the time. An additional, unknown structure is referenced with a dashed line on the right abutment. A small discharge channel is shown leading downstream from the structure, which may have been a proposed outlet structure to be built by the Seymour Water Company.

The dam appears to have been repaired and/or modified several times over the years. Repairs made on the dam appear to have included stone masonry repair, the construction of concrete caps over the stone masonry walls in the forebay area, and outlet gate repair or replacement. The forebay area and outlet works appear to have undergone significant changes since being used to provide water for the adjacent mill. The forebay area and "raceway" channel were likely abandoned as the purpose of the dam changed from an industrial supply of water power to a drinking water supply. The "raceway" channel has been filled, and the downstream mill building was presumably demolished in order to construct the current shopping center.

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