DELAWARE AND HUDSON CANAL: PAST AND PRESENT

Delaware Aqueduct, looking downstream from Lackawaxen, Pa.
(Anthony Bley, 1979)

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Preface

Designed as a system of transportation between the coal fields of Pennsylvania and the ports of New York along the Hudson River, the Delaware and Hudson Canal was one of many towpath canals constructed in the early years of the nineteenth century. Although the Delaware and Hudson, like other contemporary canals, carried a wide variety of freight, its original and primary purpose was to supply the industrial and domestic furnaces of New York with anthracite coal. From its opening in 1828 to its demise in 1898, the Delaware and Hudson Canal transported millions of tons of anthracite to the industrial and domestic furnaces of New York City, New England, and the river towns located along the Hudson. As such, the primary historical significance of the canal lies in its role in the growth and development of industry in nineteenth century America.

In addition to the overall role that the Canal played in the transportation of coal, there are other aspects of the Delaware and Hudson Canal worthy of note. As part of a series of improvement programs, beginning in 1842, four suspension aqueducts were constructed along the Canal's route. These aqueducts, the Delaware, Lackawaxen, High Falls and Neversink, were all designed by John Roebling, designer of the Brooklyn Bridge. One of these aqueducts, the Delaware is especially significant in the history of engineering. It is, according to Robert M. Vogel, historian of the Aqueduct, "The oldest suspension bridge in the United States that retains it original elements and the earliest extant example of Roebling's engineering genius".[1]

As such, it illustrates the conceptual framework in which Roebling's more ambitious and famous structures were designed. In addition to the Aqueduct another significant structure associated with the Canal was its gravity railroad. Built more as an appendage to the Canal than as an essential part of its physical plant, the Gravity was designed to connect the coal fields in the Lackawanna Valley with the Canal head in Honesdale. Shortly after the completion of the railroad in 1829, a locomotive, the "Stourbridge Lion," commisioned by the Delaware and Hudson Canal Company and built in England, was run on its tracks. Although the locomotive was found to be too heavy for the railroad's bed and was soon abandoned, it is nonetheless significant in that the "Stourbridge Lion" is the first locomotive to be run on permanent railroad tracks in America.

Presently, along the route of the Canal remain scattered sections and structures associated with the Delaware and Hudson, including aqueducts, waste weirs, locks, and sections of canal channel, towpath, and berm bank. These structures are in various state of disrepair but many are worthy of preservation because of their relationship to the Delaware and Hudson Canal system. The purpose of this paper is to present the historical background of the Canal as well as to identify extant sections of the Canal so as to insure that a significant aspect of American transportation and engineering history is preserved.

1828–1898
The Delaware & Hudson Canal
and the
Gravity Railroads connecting with the Mines

This great engineering work was the first private enterprise in the United States to cost more than a million dollars. It was constructed to bring the anthracite coal of Pennsylvania to the eastern markets and until well after the civil war, carried most of New York City's coal.

The project was first visualized by Maurice & William Wurts and financed through the influence of Philip Hone, then mayor of New York.

The canal was originally only 3' deep 20' wide at the bottom and 32' at the top. It was finally enlarged to a depth of 6', a bottom width of 32' but the top width was little changed. The original locks were 76' X 9' but were enlarged in 1850 to 100' X 15'.

As the canal was enlarged the tonnage of the boats increased: 1828-10 tons, 1840-30 tons, 1844-40 t 1850-140 tons. There were 22 aqueducts (4 shown). 136 bridges, 22 reservoirs, 16 dams, 14 feeders.

THE locks on the D & H were numbered in order westward from Rondout to Lackawaxen and from Lackawaxen to Honesdale. For the most part the boatmen referred to the lock by some name which was derived from the proprietor or from some peculiar feature nearby. The most common names were: 1—Eddyville, 2 to 4—Creek Locks, 5—Millban's, 6—Websters, 7—Rosendale, 8-9—Lawrenceville, 10—Humphreys, 11—Cole's Basin, 12-14—Nigger Locks, 15-20—High Falls, 21—Alligerville, 22—Foleys, 23—Stony Kill, 24—Middleport, 25—Port Hickson, 26—Port Benjamin, 27—Bob Decker's, 28—Chris Gitsnel's, 29—Shirley's, 30-31—Ellenville, 32—Sam Taylor's, 33—Youppy's, 34—Ostrander's, 35—Callahan's, 36—Penny's, 37—Mose Charles', 38—Louie Beardsley, 39—Joe McKane, 40—Hank Woods, 41—Jack McCarthy, 42—Bill Foster, 43—Bill Robinson, 44—Dan Hanlon, 45—Enoch Rogers, 46—Huck Rogers, 47—Will Donnelly's, 48—Will Halstead's, 49—Wm. E. Rose's, 59—P. O. Callahan's, 51-55—Neversink, 56—Mineral Springs, 57—Butler's, 58-59—Mongaup, 60—Woolsley's, 61—Pa Gene Smith's, 62—Widow Kelly's, 63—Pond Eddy, 64—Squire Van Tuyler's, 65—Decker's, 66—Lambert's, 67—Handsome Eddy, 68—Barryville, Lower 69—Barryville, Upper, 70-71-72—Gilson's Locks.

Here the canal crossed the Delaware and Lackawaxen Rivers. The first three locks on the Lackawaxen were abandoned after the completion of the aqueducts. 4-5-6—Ridgeway's, 7—Joe Tague or Tinsmiths, 8—O'Donnell's, 9—Bishop's, 10—George Rowland's, 11—Saxon's or Larson's, 12—Westfall's, 13-14—Griswold's, 15—Jim Avery's, 16—Corkonian's or Chidesters, 17—Rodgers, 18—Jim Hanner's, 19—Abe Rowland's, 20—Pat Gannons, 21—Field Bend, 22—Mike Harrison's, 23—Him Harrison's, 24—Frank Danniel's (Pat Harrison), 25—Poolpit, 26—Baisdens, 27—Carroll's (Billy O'Brien), 28—Rock Lock (Mike Connors), 29—Lower Hawley (Conklin's), 30—Upper Hawley (Hennessey's), 31—Wier's (O'Hara's), 32—McKahill's, 33—White Mills, 34—Lonsome Lock (Dan Carroll), 35—Tom Whitaker's, 36—Chris Lane's (Miles Bishop). 37—Honesdale-Twin Locks.

It should be born in mind that no two such lists of names would be the same, but those given seem to have been the most common in the last years of the canal.

At the right is a lock of the period before 1850. The lock 9'4" wide by 76' long could accommodate boats of up to 40 tons in contrast with 140 tons of later years. For the sake of clarity the bridge below the lower gates has not been shown.

The "Orange" packet was the first boat to navigate the entire canal. She left Rondout for Honesdale on October 16, 1828

The first shipment to move down the canal was a raft of pine lumber, Sept. 15, 1827, bound for Kingston.

The first shovel full of earth in the construction of the canal was turned here on July 13, 1825 by Philip Hone, then mayor of New York City.

This one of a series of historical maps published by the Wayne County Historical Society, Honesdale, Pa.

1824, Engineer Sullivan proposed starting the canal here, 1277 feet above sea level!

THE FIRST LOCOMOTIVE ever to move on rails in America, the "Stourbridge Lion", ran here August 8, 1829. Horatio Allen was engineer.

Motive Power

Sightseers came from far and wide to visit the scenic Shepherd's Crook.

The D. & H. Canal Co's. Gravity Railroad, Honesdale to Valley Junction, 30 miles. One of America's earliest railroads. It had 28 planes.

Here in 1814 Maurice and William Wurts acquired their first coal lands.

Only lack of funds prevented extension of the canal up the Delaware River to meet the Erie Canal.

Every Canaler knew that the "Pool Pit" was bottomless.

The Delaware Aqueduct is (1954) the oldest suspension bridge in use. A monument to the engineering genius of John A. Roebling. Together with three others it was built in 1848.

A map of this scale does not permit showing much detail of the gravity railroads. A large scale map is available.

The Pennsylvania Coal Co's. Gravity Railroad, 1850-85, was built as a feeder for the Canal. From Pittston to Hawley it was 47 miles long and had 22 planes.

The engineers originally proposed terminating the canal at Mill Rift and to canalize the river by means of dams and locks.

In 1823 the canal enthusiasts proposed tunnelling the Shawangunk Mountains to carry the canal across New Jersey.

140 Ton Boat.

Snubbing Post

SCALE of MILES
0 1 2 3 4 5

Modern highway numbers (6) or (17) are given to assist you in locating points of interest along the canal.

Although the canal from Honesdale to the Hudson was 108 miles long and there were 108 locks, the locks were not evenly spaced. There were no locks for sixteen miles on the summit level nor on the twelve mile Port Jervis level. On the other hand there were fifteen locks within three miles at Phillipsport.

Horizontal scale of profile is same as map. Vertical scale 200 feet to the inch.

Profile of the Canal

Lackawaxen Section — Delaware Section — Neversink Sect. — Summit Level — Ellenville — Rondout Creek Section

Delaware and Hudson Canal - Historical Background

Beginnings

The idea of the Delaware and Hudson Canal belonged to the Wurts brothers, Maurice and William, Philadelphia merchants with extensive coal land holdings in the Lackawanna Valley in Northern Pennsylvania. The Wurts' interest in anthracite developed as a result of a shortage of bituminous coal, which along with wood and charcoal, constituted the major sources of domestic and industrial fuel in the early nineteenth century. This shortage was brought about by the War of 1812, which interrupted imports from England. The shortage led to an interest in alternative sources of fuel, with attention focusing especially on anthracite coal. The Wurts brothers' search for alternative fuel sources led them to the Lackawanna Valley where coal outcroppings had been reported and where the Wurts, in turn, concentrated their land purchases.

Their original plan was to transport the coal to Philadelphia by following a series of creeks and rivers to the Delaware River, down which the coal would be floated to Philadelphia. Their first attempt however, was unsuccessful; the craft crashed against the rocks. Apparently this attempt in

1816, was followed by a successful one in which the coal, conveyed by sledges, rafts, wagons and arks, was successfully delivered to Philadelphia. In the long run however, Philadelphia turned out to be an unsuitable market for the Wurts' anthracite. Two other anthracite coal companies whose mines were more conveniently located to Philadelphia had already captured the market. The Wurts then turned their attention to New York City.[2]

The problem faced in New York was somewhat similar to the one in Philadelphia; although there was an adequate anticipated demand for anthracite, there was no reliable route of transportation by which the coal could be brought to market. At the time that the Wurts were considering their alternatives, the scarcity of transportation was a much discussed topic in the nation; would-be farmers and would-be businessmen could not get their enterprises underway because of the prohibitive cost of shipping goods overland to market. This meant that prospective markets for goods were circumscribed by the immediate geographical area surrounding the farm and factory. This made many enterprises unfeasible. One solution to this problem widely considered at the time was the construction of canals. The reason for the popularity of canals was the success of the Erie, which, though not completed

in its entirety until 1825, had been opened since 1819 along limited sections. Early reports indicated that the Erie had led to an impressive increase in business, trade and revenues in New York State. The ultimate impact of the Erie's success was that canal systems became popular solutions to the problem of transportation, so much so, that the early decades of the nineteenth century have been referred to as the Canal Era by historians of transportation.[3]

After identifying New York City as their market, the Wurts brothers systematically set out to secure the legislative, financial, and professional support they needed to get their project underway. Maurice Wurts and his "heirs and assigns" were granted permission by the Pennsylvania state legislature on March 13, 1823, to improve navigation along the Lackawaxen River by "opening, enlarging, changing, making new or improving the channel" or by constructing any "dams, locks, or any other device whatsoever" thought necessary to make navigation on the river safe. This was followed by approval on April 23, 1823, from the New York state legislature, for the construction of a canal between the Hudson and Delaware Rivers, as well as approval for the incorporation of the Delaware and Hudson Canal Company with

a maximum stock subscription of five hundred thousand dollars. An amendment on April 7, 1824, increased stock subscription to one and half million dollars and granted the Company the additional privilege of constructing the Canal up the Delaware River to the mouth of the Lackawaxen, across which slack water pools would be constructed. While obtaining the enabling legislation, the Wurts brothers took other steps necessary to see that the Canal was constructed.[4]

One necessary step was to obtain reliable information about the feasibility of constructing a canal between the Hudson River and the coal mines. Accordingly, in May, 1823, they commissioned Benjamin Wright, then chief engineer of the Erie Canal, to conduct a survey "from tidewater on the Hudson River at the mouth of the Walkill, up the valley of the Rondout, and thence over the Delaware River and thence up the Lackawaxen to a point as near the coal mines as possible...".[5] Benjamin Wright was unable to do this survey himself and in turn had his assistant, John B. Mills, go over the proposed route to "note all the difficulties and obstacles to be overcome and the probable expense of surmounting them...".[6] This was followed in September, 1823, by a more extensive survey

done by John L. Sullivan. Sullivan's report was published by the Wurts brothers along with other documents relating to the proposed Canal, in order to convince stock subscribers that the Canal was a good investment.

Sullivan's report was quite comprehensive. He thought that it was indeed practical to construct the Canal along the proposed route between the headwaters of the Lackawaxen, located near the coal mines, to tidewater on the Hudson River. His projections as to the future demand for anthracite were equally as optimistic: investors could expect that industrial and domestic consumers located in and between the cites of New York and Albany as well as along the route of the Erie and Champlain Canals would have a high demand for anthracite. As for the financial projections, he predicted that the revenues from coal sales would be enough to construct and operate the Canal and that the Canal would be able to handle a sufficient tonnage of coal to realize a profitable return to the investors.[7]

Included with Sullivan's report were estimates of all costs incurred from the actual mining of the coal to its transportation to market. The Wurts brothers' goal was to control every aspect of the anthracite business from its

mining to delivery; accordingly, they sought to unite both the mining and transportation activities under the direction of one company.[8] This was achieved; an amendment to the Pennsylvania legislation on April 1, 1825, approved the transfer of the rights and privileges of Maurice Wurts, to improve navigation on the Lackawaxen, to the Delaware and Hudson Canal Company. This was followed on April 20th by an amendment to the New York legislation, approving the transfer of these privileges. Having completed the legal groundwork for the company and obtained the necessary financial backing and professional assistance, Canal construction could finally begin.[9]

The Canal

Canal construction formally began on July 13, 1825, when Philip Hone, President of the Board of Managers of the Delaware and Hudson Canal Company and later Mayor of New York City, turned the first shovelful of earth in groundbreaking ceremonies on the summit level of the Canal, in Mamakating, New York.[10] The contracts for the Canal were let in successive sections beginning at Rondout to the mouth of the Lackawaxen on the Delaware River and then later, from the Lackawaxen to the Canal's terminus in Honesdale. Construction progressed as the additional final surveys were completed and financial

backing obtained, including a five hundred thousand dollar loan from New York State in 1827.[11]

Several changes were made in the original construction plans, however. The original plan called for the locks to be constructed of wood, but they were changed to cement and stone when cement rock outcroppings were found along the route of the Canal in High Falls and Rosendale. The route of the Canal along the Delaware River was changed from slack water navigation to an independent canal channel and an "incline plane and railway" was substituted for the section of the Canal between Honesdale and the coal mines, because of the high elevation that had to be overcome, especially over the Moosic mountains.[12]

The section between the Hudson and Delaware Rivers was completed first and the Canal company opened it up for navigation and freighting in July 1827. In the early days of operation, the canal was primarily used to transport lumber and to supply construction materials to the other section of the Canal, including lock irons and boat weighing machinery. Finally in October 1828, celebrations marking the formal opening of the Canal for its entire length were held. On October 16, a boat carrying dignitaries left Rondout for

Honesdale, to celebrate the opening of the Canal. By late November ten boats loaded with anthracite coal left Honesdale for Rondout, reaching tidewater on December 5, marking the culmination of years of planning.[13]

Once completed, the dimensions and operations of the Canal were consistent with those of other nineteenth century towpath canals. It was one hundred and eight miles long and consisted of a combination of an independent canal channel and slack water navigation. The independent canal channel, though paralleling the Delaware and Lackawaxen Rivers, and Rondout Creek, was not actually located in the water; rather it was constructed through excavations of rock and dry land. The slack water navigation sections on the other hand were actually located in the water for three miles along Rondout Creek and the point where it crossed the Delaware River. A series of dams were constructed, creating a still water pool through which boats were hauled across. The Canal was flanked on either side by a berm bank and towpath, with the berm bank located closest to the water. Some sections of the Canal's banks were walled with stone, others faced with earth and others left as jagged stone. In addition to the actual trunk of the Canal, there were numerous auxillary structures including 108 locks and several aqueducts, bridges, culverts, canal feeders,

dam-reservoirs and waste weirs.

As originally planned the Canal was to be four feet in depth, twenty feet in width at the bottom and thirty feet in width at its surface. In fact however, there was a great deal of variation in its dimensions. The bottom width ranged from fifteen to twenty feet and the upper surface ranged in width from twenty-eight to thirty-two feet. Similar variations were found in the dimensions of the towpath and berm bank. The towpath was originally to be ten feet wide while the berm bank was to slope up from the Canal's channel and be faced with earth to prevent debris from sliding into the channel. However, in those sections constructed through rock excavation, the width of the towpath narrowed and the berm bank rose perpendicular to the Canal with no particular slope. Moreover, the rock was left jagged. This construction not only provided little protection from sliding debris but damaged the canal boats when they bumped against the banks. [14]

The source of these problems was the topography of the land. Long sections of the Canal were constructed through solid rock and gravel soil. In the rock excavations it was difficult to make the excavations as deep or as wide as

planned while in the sections excavated through gravel soil, it was difficult to get the Canal's banks to retain water. As a result, clay linings had to be applied to the banks. These clay linings however, tended to decrease the dimensions of the Canal's prism. These structural problems became glaringly obvious once the operations commenced. Although the canal was supposed to be wide enough to allow boats to pass one another in opposite directions, some sections were too narrow for this. And because of the difficulty in getting the canal's banks to retain water, even after the clay lining had been applied, a full head of water could not always be maintained.[15] As a result, the boats could not always carry their full thirty ton capacity. The problem of water retention got to be such a serious one that it was mentioned in the Company's annual reports. The report for 1827 noted in frustration that:

> In many cases, it was difficult to discover the leaks, especially in some of the large natural basins, for whilst no mositure appeared on the outside of the towing path bank, the water gradually subsided in the Canal, and after the lapse of half of a day or more, showed itself at various distances in the valley below. From these causes, the transportation on the Canal was chiefly limited to short distances from tide water, some few boats only extending their trips to Wurtsborough, 40 miles from tide.[16]

The Gravity Railroad and the Stourbridge Lion

Instead of extending the Canal up to the headwaters of the Lackawaxen, the Canal Company constructed a sixteen mile railroad from the boat basins in Honesdale to the coal mines in Carbondale. This route involved passing over the Moosic Mountain and overcoming a net elevation of nine hundred and twenty feet. The original plans for the railroad called for eight planes and levels with the first five planes and levels ascending the mountain from Carbondale and three planes and levels descending the mountain into Honesdale. Stationary engines located at the summit of each of the five ascending planes hoisted the railroad cars up the mountain while the railroad cars on the three descending planes were run by the force of gravity with their velocity controlled by brakes made of "bent sapling applied directly on the wheels".[17] Horses pulled the railroad cars along the five ascending levels, and steam locomotives were to be used on the three summit and descending levels. As it developed however, the steam locomotives were soon replaced by horses.[18]

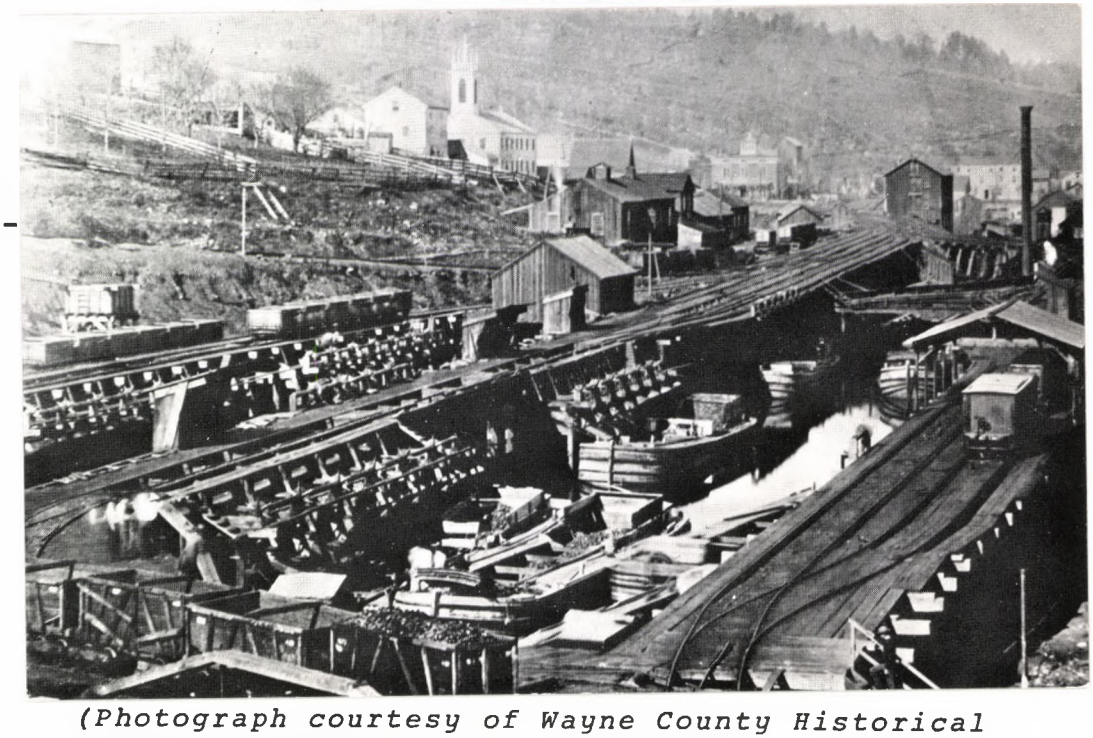
At the time that the Canal Company made the decision to use steam locomotives very few railroads of any type were in operation in the United States. Those that were in operation consisted of horse drawn cars over railroad tracks. In view

of this, the Company decided to send Horatio Allen to England where steam locomotives were already in operation. In England, Allen commissioned the construction of four locomotives; the "America" from the Stephenson Company and the "Delaware", the "Hudson" and the "Stourbridge Lion" from Foster, Rastrick and Company. Though the "Stourbridge Lion" was not the first of the four to arrive in the United States, it was the only one to be run on the tracks. Two test runs conducted by Allen indicated however that the locomotives were too heavy for the roadbed, resulting in the substitution of horses for the steam locomotives. Historical research has subsequently indicated that the "Stourbridge Lion," so named because of the red lion's head painted on its boiler plate, was the first steam locomotive to be run in the United States. Presently parts of its boiler are being preserved at the Smithsonian Institution's Museum of History and Technology in Washington, D. C.[19]

Canal Operations

Navigation along the Canal began in Honesdale at the boat basins where the coal was transferred from the railroad cars into the coal boats. Here the boat's name, identification number and time of departure was recorded. A permit was issued and the boat sent on its way to Hawley. At Hawley the

boats were weighed and their tonnage recorded. In travelling to Rondout, the boats followed the Canal's route down the banks of the Lackawaxen until its confluence with the Delaware. Here it crossed the Delaware by slack water navigation and continued down the Delaware to Port Jervis. From Port Jervis the Canal travelled in an northeasternly directon, through the valley and along Rondout Creek to Eddyville. From Eddyville the boats were towed by steamer to Rondout. At Rondout the coal was unloaded and sent by steamship to market. After 1850 however, when enlargements of the Canal's trunk and locks were completed, the boats travelled directly from Rondout to markets along the Hudson River including,



Early view of the Upper Boat Basin in Honesdale showing both the coal railroad cars and boats.

(Photograph courtesy of Wayne County Historical Society, Honesdale, Pa.)

New York City, Albany and Troy, Poughkeepsie, Newburgh, and Peekskill. Generally a roundtrip between Honesdale and Rondout took from ten to eleven days. Six more days were required however, if the boats went directly to New York City. The coal boats travelled through the Canal at a speed of two to three miles per hour. Faster speeds were not permitted because the wash created was damaging to the Canal's banks.[20]

Any boat that travelled the entire route of the Canal between Honesdale and Rondout was locked through one hundred and eight locks that ranged in elevation from eight to twelve feet. Most of the locks had wood linings embedded in stone but a few of them were made entirely of cut stone and cement masonry. Basically the locks were "enclosures in the Canal with gates at each end"[21] which raised or lowered the canal boats, depending upon the direction they were headed. When the Canal was first completed the locks were nine feet in width and seventy-five feet in length between the gates but in 1850 their dimensions were enlarged to fifteen feet in width and one hundred feet in length. Originally, both the upper and lower gates of the locks consisted of a pair of mitre gates which met at an angle when closed and swung out to the sides of the Canal when opened. Each pair of gates were operated by balance beams which extended off

the mitre gates and required two locktenders to operate. In 1855 the Canal Company replaced the upper gates and improved the operation of the lower ones: the upper mitre gates were replaced by a drop gate which rested in the Canal's bed when opened and balance beams on the lower gates were replaced by a hand operated machine. Now one locktender could operate both the upper and lower gates simultaneously, without assistance. When travelling down the Canal from Honesdale, the boat would enter the lock by passing over the lowered drop gates. Once inside the lock, the boat was snubbed on the snubbing post to prevent it from hitting against the sides of the lock. Once the upper drop gate was raised, the paddle gates located in the bottom of the lower gates, were opened until the water level inside the lock equalled the water level in the canal channel below the lock. Once equalized, the paddle gates in the upper drop gate were opened so that the ensuing gush of water would "flood" the boat out of the opened lower gates. The boats was then sent on its way down the Canal to the next lock which was kept open day and night, with the exception of Sundays, during the peak years of the Canal's operation.[22]

In addition to operating the locks, the locktenders, had a host of responsibilities designed to keep the Canal in good

order. First, they were responsible for the water level of the Canal below their locks: if the water level was too low they opened the sluiceways, that ran the entire length of the Canal, to let in additional water; if the water level was too high, they opened the waste weirs and let the excess water flow out.[23] They were to be especially vigiliant to report breaches and leakages in the Canal's banks. Equally as important were their responsibilities in enforcing the rules and regulations of the Canal Company. All boats were required to have the necessary navigation permits; careless employees or those who damaged the Canal or its appendages or unloaded anthracite without permission were to be reported to the Superintendents. One rule apparently not vigorously enforced governed the crew's composition; the Company's rules clearly stated that the boats were to be manned by three males, but in fact, both women and girls could frequently be found among the boats' crews.[24]

Although other goods such as cement, stone, brick, lime, lumber, lead, plaster, leather, glass, flour, oats, wheat, and general merchandise were transported along the Canal, most of the boats in operation transported coal for the Delaware and Hudson Canal Company.[25] The boats were operated on a

contractual basis. The boats were ordered and built according to the specifications of the Company and sold to the boat operators on an installment basis. Out of the money earned for each trip, a portion of the proceeds were deducted and applied towards the price of the boat. The boat operators were compensated according to the number of trips made per season and the days it took to make each trip; the greater the number of trips made and the fewer the number of days it took to make each trip, the more the boat operators received per ton of coal transported. Those operators who failed to make at least two complete trips per month, forfeited their contracts. In addition to deducting installment payments on the boat, the Canal company withheld a portion of the boat operator's money until the end of the season "provided that the conditions of this contract have been faithfully performed and complyed with...". Out of the money earned each trip however, the boat operators were expected to pay the crew's wages and provide their food while navigating the Canal. On the return trip up the Canal, the boat operators were permitted to take aboard "passengers, their baggages and furniture as well as freight "with the exception of sand, lime and cement...".[26] The Canal Company however, reserved the privilege of shipping up to three tons of freight on the return trip without compensation to the boat operators.[27]

One persistent problem encountered on the Delaware and Hudson Canal throughout its history was the shortness and unpredictibility of the navigation season. Normally the Canal was in operation for seven to eight months ,beginning in late April or early May and ending in early December. The exact opening and closing dates depended upon the weather particularly since the Canal's waters were likely to be frozen over in the winter. Those sections of the Canal located either in or immediately adjacent to bodies of water, particularly the Delaware and Lackawaxen Rivers and Rondout Creek, were throughout the Canal's history, subject to damage as a result of floods, freshets and ice. Moreover, along the summit level, the Canal was subject to frequent droughts. This condition was somewhat alleviated by the construction of several feeders but the feeder system never completely solved the problem. In 1854, for example, the Canal company lost thirty-nine days of navigation due to a drought on the summit level.[28]

In responding to the emergencies involving breaches in the Canal's banks, the Canal company developed an elaborate contingency plan. Stop gates which normally lay flat in the Canal bed were raised to isolate the affected section. This prevented both the water from running out of the undamaged

sections as well as further damage to the Canal banks. Meanwhile, boats in the affected area were halted and docked alongside the banks. The Canal superintendent in the affected area directed the repair of the banks, recruiting labor from the nearby communities. During harvest seasons or when the breach occurred in sparsely populated areas, the boats' crew were required, as part of their contractural agreement with the Delaware and Hudson Canal Company, to go immediately to the affected areas and help in the repair of the Canal's banks. Once the repairs were completed, the water was readmitted into the channel and the boats sent on their way. An indication of how disruptive these disasters were to the Canal's operation was the 1853 season when seven floods, one freshet and seven Canal bank breaches caused the Company to lose thirty-one working days.[29] Navigation along the Canal was at best-imperfect.

Anthracite Coal

In many ways, the success of the Delaware and Hudson Canal depended upon the demand for anthracite coal. Although other goods were transported down the Canal, the prosperity of the Canal Company and the success of the Canal depended always upon a sufficient market for anthracite. The Company was keenly aware of this relationship; Sullivan, in presenting

his engineer's report to the prospective stock investors had focused not only on the feasibility of constructing the Canal along the proposed route but in addition, on whether there was a sufficient supply and demand for anthracite coal to make the Canal system a profitable investment as well.[30] Accordingly, it is not surprising that a considerable amount of attention was paid by the Board of Managers of the Canal Company to increasing the market for anthracite. One important way that the Canal Company did this was to sponsor scientific and technological demonstrations and experiments on the combustion qualities of anthracite. These investigations were necessary because of the perculiar nature of anthracite. Unlike bituminous and other soft coals, anthracite was difficult to burn. Consequently, special grates and stoves had to be developed. Not until the technology necessary to efficiently burn anthracite for both industrial and domestic purposes was developed did the demand for anthracite increase sufficiently to enable the Canal to be used to its full capacity.

Actually, even before the Canal Company was formed, limited developments in this direction had already been made. Apparently, Jesse Fell, a blacksmith in Wilkes-Barre, Pennsylvania, had, in 1803, constructed a special grate that regulated

the amount of draft that came into contact with the coal and in doing so, demonstrated the ability of anthracite to burn. This grate became the prototype for more complex grates used for both domestic and industrial purposes. Inspite of Fell's success, however, anthracite was not in general use when the Canal was completed.

The Delaware and Hudson Canal Company, aware of the problems with anthracite, began a program to introduce anthracite to the public. In 1825, when the first stock subscription for the Company was let, public demonstration of anthracite's coal combustion properties was held at the Tontine Coffee House in New York City. In the Annual Report for 1831, the Board of Managers noted that they had hired a agent to visit "manufacturing establishments" to demonstrate "the means of using" anthracite as well as to get the manufacturers to try Lackawanna coal. This agent was apparently paid two hundred dollars per month and sent to both New York and New England.

Most significantly, however, was the Company's progresss in the promotion of the use of anthracite in steamboats. The annual report for 1827, had hinted that the Company was closely watching experiments in the use of anthracite in steamboats but the full extent of the Company's activities in this

area were revealed later. In the annual report for 1831, the Company reported that four ferries in New York - three on the East River and one on the North (i.e. Hudson) River, were using Lackawanna coal and that they anticipated a fifth to soon adopt it. The Canal Company in an effort to hasten the general adoption of anthracite in steamboats, sponsored technological experiments in the field by granting free coal for experimental use in one ferry and by financing the construction of special grates for another. Their most significant achievement, however, was revealed when they announced in the annual reports of 1834 and 1835 that they had contracted with Dr. Eliphalet Nott, an inventor who held several anthracite stove patents, to "start a passage boat of the first class on the North River, using Lackawanna coal, under his Patent Tubular Anthracite Coal Boilers." In exchange, Dr. Nott was to receive one thousand shares of Company stock. In 1840, the Company reported yet another use of their product. Iron was now being successfully smelted with anthracite.[31]

The Company's campaign resulted in the increase in the demand for anthracite. In 1830, the first full year of the Canal's operation, only 43,000 tons of coal had been shipped down the

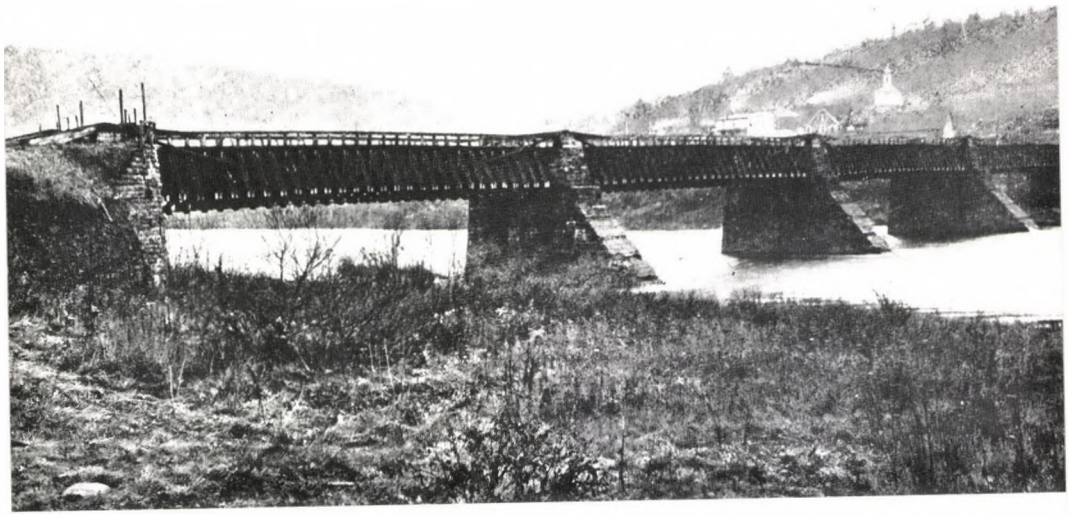
Canal. By 1833, this amount had increased to 111,777 Tons.[32] As a result of these developments, the Board of Managers confidently announced to the stockholders in 1839 that:

> ...the Company occupies a position of great strength and permanent prosperity ....The Company's market for coal is now sufficiently extended and established to insure a demand even under adverse circumstances that will annually provide for dividends, and this market is daily increasing.[33]

Expansions and Improvements

Beginning in 1842, and extending into the next decade, the Delaware and Hudson Canal Company began a series of expansion and improvement projects in response to the increased demand for anthracite. The first of these programs was designed to increase the depth of the Canal from four to five feet, thereby permitting the navigation of boats carrying forty tons of freight. When this program was completed in 1844 another was launched, this time to increase the Canal's depth to five and one half feet so as to permit the navigation of boats carrying fifty tons of freight. During both programs, the construction was carried out during the winter months, permitting the Canal to operate without interruption. In addition to expanding the Canal's dimensions, its channel was improved and its banks strengthened, thereby making for

smoother navigation. During this period, the Company also expanded the capacity of the gravity railroad to insure that the tonnage capacity of the railroad matched that of the Canal.



Early photograph of Delaware Aqueduct (Courtesy of Wayne County Historical Society)

The third expansion and improvement program began in 1847. During this phase, a number of improvements were carried out simultanelously: the banks were lined with stone along the Delaware and Lackawaxen Rivers; new boat basins were constructed; the towpath was increased from ten to fifteen feet in width; the bottom and upper surface of the Canal were

increased to thirty and forty-eight feet respectively; the width of the Canal immediately above and below the locks were expanded; the berm banks were improved; and sections of the Canal were realigned. The realignment at High Falls was necessitated by the fact that the locks followed each other in a zig-zag line which required boat operators to change direction several times in between the locks. During the realignment one lock was eliminated and the other locks were rebuilt on a slight curve relative to each other with a towpath constructed on either side of the locks.

The most significant change made during this program was the construction of four aqueducts, one at High Falls and the others across the Neversink, Delaware and Lackawaxen Rivers. The High Falls and Neversink aqueduct replaced two older structures while the Delaware and Lackawaxen aqueduct were designed as a joint project to eliminate the delays caused by the slack water pool across the Delaware. At the slack water pool, the Canal crossed the Delaware at a point above the mouth of the Lackawaxen thereby permitting the Canal to cross over the banks of the Delaware without having to cross over the Lackawaxen. When the Delaware Aqueduct was constructed however, it was placed below the

mouth of the Lackawaxen, necessitating the construction of another aqueduct to cross over the Lackawaxen River. In constructing these aqueducts considerable changes were made in the line of the Canal. Three locks were eliminated on the Lackawaxen side while three new locks, carrying the Canal to the Delaware Aqueduct were constructed on the Delaware River. In addition, the half-mile stretch of the Canal going up the Delaware to the mouth of the Lackawaxen was eliminated. Of the four aqueducts, the Delaware has received the greatest amount of scholarly attention, no doubt due to the fact that only one abutment each remains of the High Falls, Neversink and Lackawaxen Aqueducts, while the Delaware Aqueduct still retains much of its original structure.[34]

The major significance of the Delaware Aqueduct, is that it is an early example of many of the techniques which were developed by John Roebling, techniques which illustrate the conceptual framework in which his later structures were developed.[35] In designing the Delaware Aqueduct, Roebling worked within a number of constraints. Frequent floods, ice floes and river raft traffic along the Delaware required the construction of the suspension structure with a minimum number of piers so as to allow for maximum clearance on the

Delaware[36] River. These limitations necessitated the construction of a suspension structure with longer spans than were possible by more conventional masonry and truss suspension systems. In developing these long spans, Roebling used wire cables. In comparison to contemporary designers of wire cable suspension structures, Roebling's design was unique. His wire cables were composed of several wire ropes that themselves were composed of numerous individual strands. The strands were laid parallel to one another so that for the entire length of the Aqueduct, the relative position of each strand was maintained. These cables were strung in the air on the spot by a machine, designed and constructed by Roebling, that moved from one anchorage to another, maintaining the relative position of the strands as well as adjusting them for their proper curvature and sag. This parallel design allowed each of the strands of the rope and each rope of the cable to carry a proportionate amount of the load. These strands were then compacted so as to form a solid cable that was then wrapped in another layer of wire. The compaction of the wire into a solid cable, gave the bridge "stiffening" qualities that allowed it to withstand the cumulative vibrations of the wind and moving loads. The wrapping of the cables in another layer of wire protected the cables from the[37] elements without necessitating their encasement in masonry.

Additionally illustrated in the Delaware Aqueduct was Roebling's recently patented anchorage system. The contemporary design for anchorages left the cable ends exposed thereby requiring their periodic inspection. Roebling however, set the ends of the cables in concrete encasements thereby eliminating the necessity for maintenance.[38] This design was repeated in the High Falls, Neversink and Lackawaxen Aqueducts.

These innovations in design facilitated the building of even longer and more durable suspension structures, both by Roebling and his successors. As such, the Delaware Aqueduct is significant, not only for its association with the Delaware and Hudson Canal, but for the technical and engineering innovations that it illustrates, both relative to Roebling's professional career as well as for the technical evolution of suspenion structures, in general.

Cables and anchorage, Delaware Aqueduct
(Anthony Bley, 1979)

Railroads and the Decline of the Canal

The expansion and improvement of the Canal's physical plant made possible the even greater prosperity of the Canal Company. By 1859, 1,006,986 tons of coal were being transported down the Canal, 494,209 of which belonged to the Delaware and Hudson Canal Company. The remainder belonged to the Pennsylvania Coal Company with whom the Delaware and Hudson Canal Company, in anticipation of the Canal's enlargment, contracted in 1847 to ship their coal to tidewater as well. In the following decades however, there was a slow but sure shift away from the Canal Company's reliance on its original system of transportation. While the Company had been founded on canal transportation it was increasingly using railroads to get its coal to market.

There were several reasons for this shift. Though the Canal had met the Company's needs, it has throughout its history even after the enlargment and improvement program was completed, been plagued by certain persistent problems. The Canal was completely incapacited during the winter months; it was periodically paralyzed by droughts and floods; and navigation speeds were never able to exceed three miles per hour. Moreover, and what seemed to bother the Canal Company most, was that it was limited in the markets it reached. The Company was especially concerned that while its competitors, through

the use of railroads, were expanding their markets; and even competing with the Delaware and Hudson Canal Company in markets that they had previously held exclusively; the Canal Company was not able to expand its markets beyond those it reached at tidewater and along the Hudson River.

To remedy this situation, the Delaware and Hudson Canal Company took several courses of action. In September, 1869, it contracted with the Erie Railraod, for the transportation of the Company's coal from Honesdale to Weehawken during the winter months. This allowed the Delaware and Hudson Canal Company to reach its customers during the winter . Additionally, the Erie Railroad Company was "...construct a railroad from Carbondale to their main line at Susquehanna, to be completed on or before the first day of June, 1870 and thereafter to transport coal for us on favorable terms from our mines to Rochester and Buffalo"[39]. This contract with the Erie, was the first in a series of agreeements to purchase, contruct and perpetually lease numerous railroad lines and their feeders, including the Albany and Susquehanna, the Rensselaer and Saratoga, and the New York and Canada lines. The new markets reached by these lines were in Canada, upstate New York, and New England, and though some of them were already being reached by the Canal,

the railroads gave the Canal Company several advantages. First, these railroads provided a year-round means of distributing the Company's anthracite. Moreover, by controlling these strategic lines the Company denied other anthracite companies the competitive advantage of controlling them. Additionally, as with the Canal, the Company was able to earn extra revenues by transporting products for other companies and individuals along the routes.[40] In 1870 the Board of Managers revealed its conception of the railroad lines in their statement to the stockholders:

> It has become evident to the managers that, to meet the rapid increase in consumption east and north of the mines, transportation facilities would require to be largely extended, either by the enlargement of the Canal - involving a large expenditure - or by the possession or control of a railroad line running nearly parallel therewith. The enlargement of the Canal would give increased capacity only, while the possession of the Albany and Susequehanna Railroad gives, in addition, markets that are practically closed to the Canal, a much-needed winter communication, and protects us from competition that might, under possible combinations have seriously affected the value of our present improvements.[41]

With this, the company proceeded rapidly to acquire and control still other railroad lines.

The annual reports for later years are filled with references to the Company's plans to improve upon its existing

railroad network. They spent large sums in extending the routes of existing lines; in constructing new feeder lines; in double tracking and standardizing the gauge of the tracks; and in purchasing new locomotives, passenger and coal cars. During the same period however, there is very little mention of the Canal, except to point out the occasional droughts and delays along its route.[42] This interest in railroads to the exclusion of the Canal spelled the end of the Canal. Finally in 1898, the Board of Managers announced to the stockholders, that the cost of transporting coal along the Canal relative to railroads, was too expensive, and "The cost of the Canal has therefore been charged off, and no longer stands as an asset on your books."[43] Actually the Canal Company had considered abandoning the section of the Canal between Honesdale and Port Jervis as early as 1866, and replacing it with a railroad along the same route, but nothing ever developed with this plan.[44] In any case, in 1899 the name of the Company was shorted to the Delaware and Hudson Company.

The last shipment of coal left Honesdale for tidewater in November, 1898. On June 13, 1899, the Canal and "all its franchises, rights and privileges" were sold for ten thousand dollars to S. D. Coykendall, president of the Cornell Steamboat

Company. In 1900, a short section of the Canal between Ellenville and tidewater was opened for limited navigation to carry local products, including provisions, wood, bricks, and Rosendale cement. This continued until 1904 or, shortly after. Meanwhile, the Canal was being transformed; boat basins and sections of the Canal bed were filled in; foot bridges were erected over the Canal's banks; and the stonework along its banks and in some of the locks were removed spelling the end of the Canal as a viable transportation system.[45]

PRESENT CONDITIONS

Overall, the present conditions of the Canal can be described as variable; along the original 108 mile route, only scattered sections of the Canal and its appendages are extant. Most of the Canal channel has been either filled in or is dry; two notable exceptions however are sections in Alligerville and Cuddebackville. Of the four Roebling Aqueducts, only the Delaware retains most of its original structure. Only one abutment remain each of the Aqueducts at High Falls, and over the Neversink and Lackawaxen Rivers. Fine speciments of the locks, however, remain throughout the Canal's route.

In 1965, five sites and structures of the Delaware and Hudson Canal received the National Historic Landmark designation under the theme of "transportation and communications" in recognition of the role of the Canal in the transportation of anthracite coal. These sites are located in High Falls, Alligerville, Cuddebackville, Minisink Ford, New York, and Lackawaxen and Honesdale, Pennsylvania. In September, 1979, I along with Gene Peluso, a landmark specialist from Heritage Conservation and Recreation Service, and Anthony Bley, a photographer from the Army Corps of Engineers, visited the designated areas to determine their present conditions. In

addition to visiting the designated sites, we visited two areas that had not been designated but had extant sections of the Canal. Moreover, we obtained a copy of a report, sponsored by Sullivan County, New York which listed extant structures and sections of the Canal in that County. Below is a summary of the conditions of the Canal at these sites.

High Falls

The designation at High Falls includes an abutment from Roebling's High Falls Aqueduct and five locks numbers 16-20. The locks are of the cut stone variety and follow each other in succession over a one-mile distance. The locks are owned by the High Falls Fire District and are maintained by the Delaware and Hudson Canal Historical Society. The Delaware and Hudson Canal Historical Society, located in High Falls, New York, has developed a "loop trail" that follows the route of the locks and has photographs and brief description of the Canal affixed to the trees along the way. The intervening land between the locks is privately-owned, though presently, the High Falls Fire District maintains a right-of-way agreement with the property owners so as to allow the public to view the locks. Lock #16, which has the National Historic Landmark plaque affixed to it, is immediately accessible from the main road through High Falls. The other locks

are not located near a road and are most accessible when the foliage is "down". Located a few yards north of lock #16 is lock #15 which is privately owned.

Lock #16, High Falls, New York
(Anthony, Bley, 1979)

Between High Falls and Alligerville: Lock #21

Lock #21 was abandoned by the Canal Company in 1848 when the Canal was rerouted in the area. Unlike the other locks

on the Canal which were enlarged in 1850 to dimensions of 100 feet in length and 15 feet in width, this lock was designed to be seventy-five feet in length and nine feet, in width. Presently, the lock is privately owned and inaccessible, except by crossing private residential property. Its stone walls are intact, though it has several trees growing in its bed.

Old lock #21, Between High Falls and Alligerville
(Anthony Bley, 1979)

Alligerville

The National Historic Landmark designation here is for the Peter Davis boat basin and a two-mile section of the Canal of which the first 5,000 feet was water-filled. Presently, the boat basin contains water however, a flood and storm in November, 1977 caused the towpath and bank to collapse into the Canal's channel for approximately 4,000 feet, leaving approximately 1,000 feet of water-filled Canal channel remaining. The entire two-mile section of the Canal is privately owned by about fourteen individuals. The remaining 1,000 feet is water-filled and is inaccessible except through private residential areas.

Showing Section of the Canal damaged by Storm Alligerville, N.Y. (Anthony Bley, 1979)

Peter Davis Boat Basin at Alligerville, New York
(Anthony Bley, 1979)

Photograph:

Water filled Canal channel in Cuddebackville New York - (Anthony Bley, 1979)

Cuddebackville, New York

The landmark designation in Cuddebackville includes an abutment from Roebling's Neversink Aqueduct; approximately one mile of water filled Canal feeder and approximately two miles of Canal channel, one mile of which is water filled and one mile of which is not. The Cuddebackville section of the Canal is the most scenic of the remaining sites along the Canal. Presently, the Canal and its related structures are being purchased by Orange County in connection with a recreational park. A former blacksmith's shop located near the Canal has been restored and is now being occupied by the Neversink Valley Area Museum. The Cuddebackville section is accessible by public road.

Water filled Canal channel in Cuddebackville New York - (Anthony Bley, 1979)

Top photo:

Former blacksmith's shop, now occupied by Neversink Valley Area Museum, adjacent to Canal in Cuddebackville, New York - (Anthony Bley, 1979)

Bottom photo:

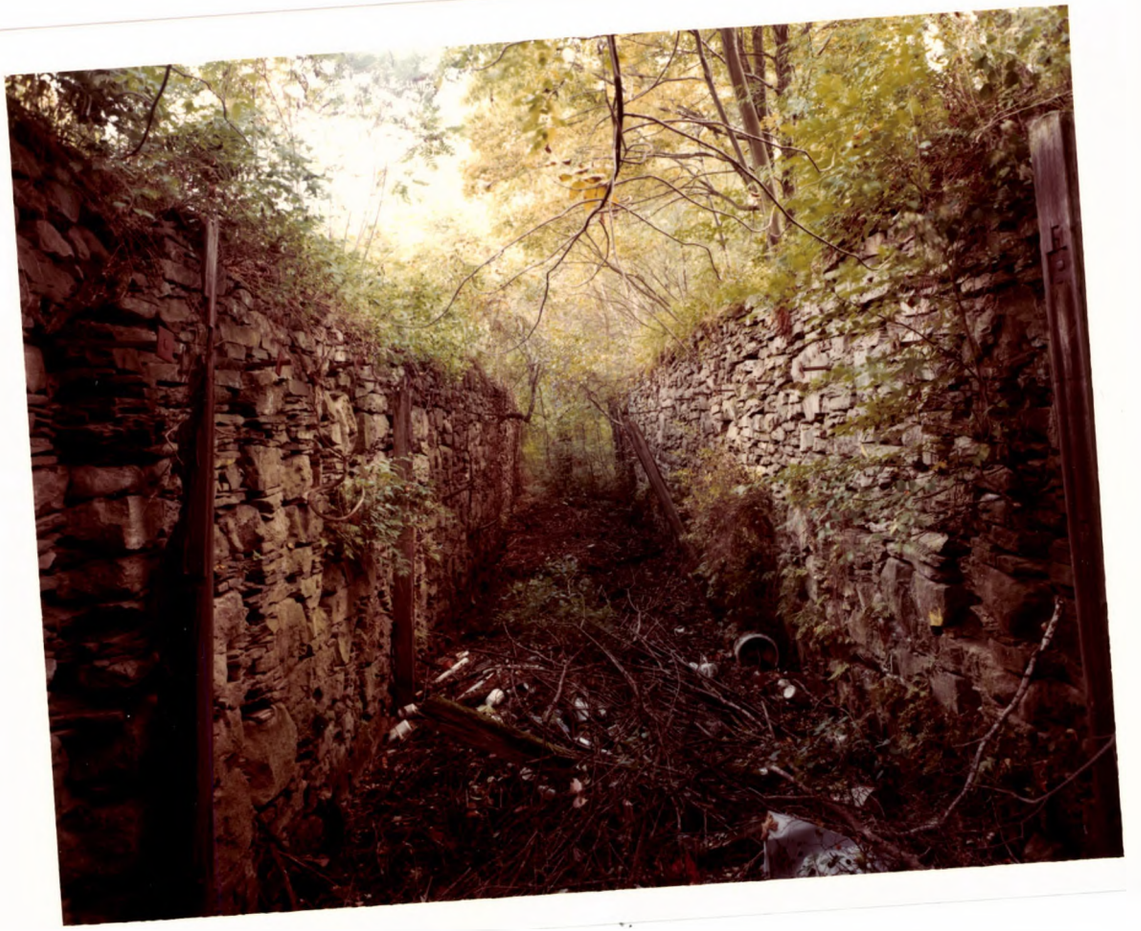
Abutment of Roebling's Neversink Aqueduct Cuddebackville, N. Y. - (Anthony Bley, 1979)

Abutment of Roebling's Neversink Aqueduct Cuddebackville, N.Y. (Anthony Bley, 1979)

Former blacksmith's shop, now occupied by Neversink Valley Area Museum, adjacent to Canal in Cuddebackville, New York (Anthony Bley, 1979

Minisink Ford, New York

Two notable sections of the Canal here are the Delaware Aqueduct and a lock. Much of the original structure of the Roebling Aqueduct is intact. The National Park Service is presently in the process of acquiring the Aqueduct for inclusion in the Upper Delaware River Wild and Sceni River project. Additionally, located several yards east of the Roebling Aqueduct, between the main road and the Delaware River is a Canal lock. The stonework of the lock is intact, though the lock is littered and overgrown with foliage.



--1 lock near Delaware Aqueduct, Minisink Ford, New York (Anthony Bley, 1979)

Sullivan County, New York

During the summer of 1978, the Sullivan County Department of Planning sponsored a survey of the extant structures of the Delaware and Hudson Canal within Sullivan County. Inventoried were three aqueducts, five dam-reservoirs, one towpath cross-over, seven locks, one waste weir and twenty one buildings. The conditions of Canal locks #40 and #42 (Phillipsport) and #68 (Barryville) were described as good, while locks #43, #45, #50 (Phillipsport) were described as being in fair condition. The condition of both the Delaware and Homowack Kill Aqueduct (Minisink Ford and Phillisport respectively) were described as good, while the Beaver Brook Aqueduct (Highland) was described as being deteriorated. Masten Pond Dam (Mamakating) was described as being in good condition, while Yankee Pond Dam (Yankee Lee), Lord's Pond Dam (Rock Hill), McKee Pond Dam and Wolf Pond Dam (Phillisport) were described as being in excellent condition. Both the Homowack Towpath Cross-over in Phillisport and a waste weir in Mamakating were described as being in excellent condition. (The twenty one buildings range in condition from fair to excellent but their exact relationship to the Canal is not clear.)

Lackawaxen, Pennsylvania

The major site here is the remains of Roebling's Lackawaxen Aqueduct. The original aqueduct consisted of two abutments and one mid-river pier. The mid-river pier is gone and only a few cut stones remain of the east abutment. The west abutment with about 200 feet of the stonework of the canal embankment leading from it, still stands. The canal embankment is then intersected by Kelly Road, but picks up again on the other side. It then runs about 3/10 of a mile parallel to Kelly Road. This latter section is littered and overgrown but the stonework is intact and probably preservable. The site is accessible by public road.

West abutment of Lackawaxen Aqueduct, Lackawaxen, Pa.
(Anthony Bley, 1979)

Top

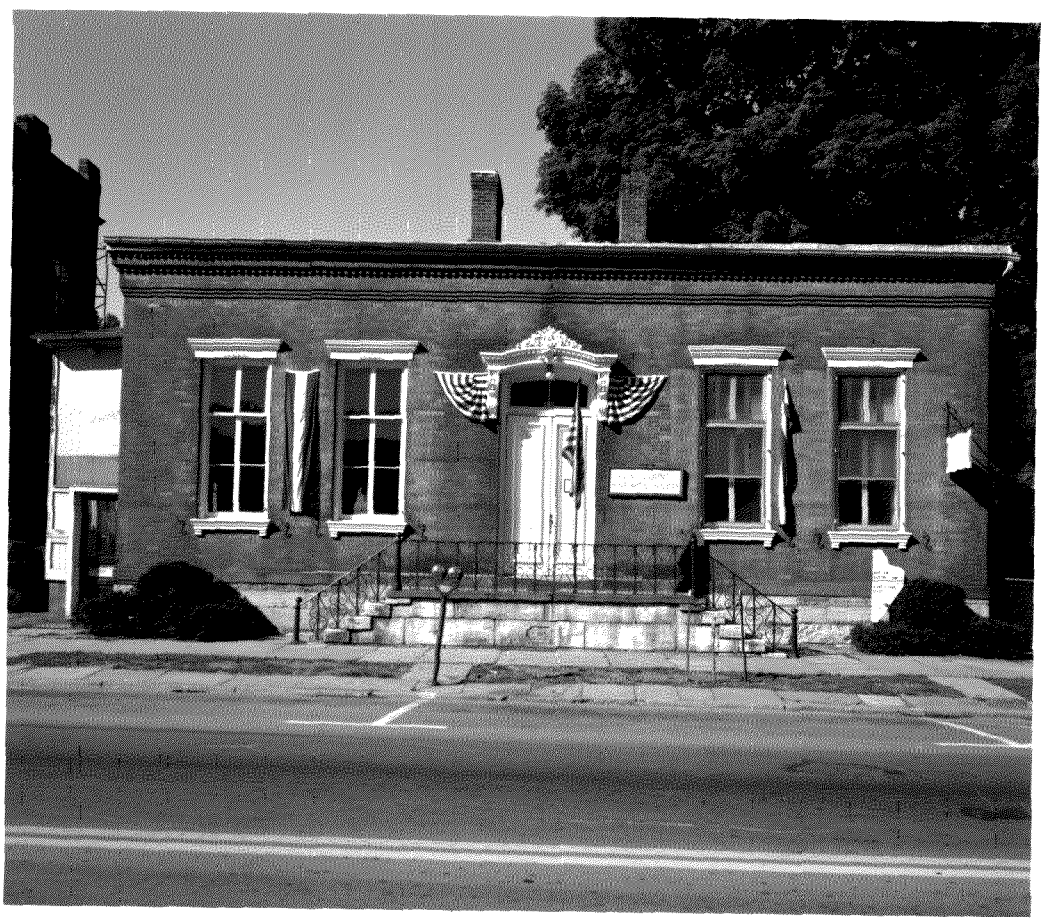
Interior view of west abutment, Lackawaxen Aqueduct
(Anthony Bley, 1979)

Bottom

Stonework of Canal embankment, near remains of Lackawaxen Aqueduct abutment
(Anthony Bley, 1979)

Honesdale, Pennsylvania

The National Historic Landmark designation here is for the former offices of the Delaware and Hudson Canal Company, abandoned by the Company when the Canal was closed in 1898. The building is presently owned by the Wayne County Historical Society and is maintained as a museum. On display here are artifacts and diagrams of the original Canal.



Wayne County Historical Society Honesdale, Pa.
(Anthony Bley, 1979)

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NOTES

[1]"Delaware Aqueduct, 1848" p. 151 in Robert M. Vogel A Report of the Mohawk Area Survey Washington, DC: Smithsonian Institution Press, 1972.

[2]Accounts of the Wurts brothers interest in anthracite can be found in Century of Progress Albany, New York: J.B. Lyon Company, printers, 1925. pp. 9-23; Edwin D. LeRoy The Delaware and Hudson Canal: A History Honesdale, Pennsylvania: The Wayne County Historical Society, 1950 pp. 3-13; Alfred Mathews, History of Wayne, Pike and Monroe Counties, Pennsylvania, Philadelphia: R. T. Peck &Company, 1886. pp. 226-232; Manville B. Wakefield, Coal Boats to Tidewater: The Story of the Delaware and Hudson Canal South Fallsburg:New York: Steingart Associates, printers, 1965 pp. 2-3.

[3]See Alvin F. Harlow Old Towpaths: The Story of the American Canal Era New York: D. Appleton and Company, 1926 pp. 33-42. for a discussion of the transportation problem in 19th century America. See Harlow, Old Towpaths pp. 44-75, for a discussion of the construction and importance of the Erie Canal.

[4]See "Charter of the Delaware and Hudson Canal Company with the Several Acts Supplementary to the Same" pp. 1-17, 18-32,and 33-34, for New York and Pennsylvania legislation.

[5]"Report of the Messrs, Benj. Wright and J.L. Sullivan, Engineers engaged in the Survey of the Route of the proposed canal from the Hudson to the Head Waters of the Lackawaxen River" Philadelphia 1824 p. 23.

[6]Ibid.

[7]Ibid, pp. 1-22.

[8]Ibid. p. iv.

[9]"Charter of the Delaware and Hudson Canal Company..." pp. 37-40. and 41-42.

[10]"Luncheon in Celebration of the One Hundreth Anniversary of the Founding of the Delaware and Hudson Company, 1823-1923", inside front cover and LeRoy, Delaware and Hudson Canal p. 14.

[11]"Annual Report of the Board of Managers of the Delaware and Hudson Canal Company to the Stockholders for the Year 1827" pp. 3-5.

[12]"Annual Report...for the Year 1825" pp. 4, 8, 12-13, Harlow Old Towpaths p. 299 and Wakefield, Coal Boats to Tidewater pp. 171-172.

[13]"Annual Report...for the Year 1827" p. 11; Harlow Old Towpaths p. 191; LeRoy Delaware and Hudson Canal p. 21 and "Luncheon in Celebration...", inside front cover.

[14] Good descriptions of the Canal and its dimensions can be found in "Delaware and Hudson Canal Company vs. Pennsylvania Coal Company:Pleadings and Testimony" volumne I pp. 179-187; 199-203; 337-338 and volumne V pp. 2894-2895, 2951. See also, Century of Progress, pp. 38 and 67.

[15]For discussion of the topography of the land along the Canal's route and the problems it caused see "Delaware and Hudson Canal Company vs. Pennsylvania Coal Company" volumne V pp. 2686-2687, 2767, 2877-2879, 2909 and 3029-3042.

[16]"Annual Report...for the Year 1827" p. 11.

[17]LeRoy,Delaware and Hudson Canal p. 27.

[18]Descriptions of the gravity railroad and the "Stourbridge Lion" can be found in LeRoy,Delaware and Hudson Canal pp. 23-32; 75-76; Mathews, History of Wayne, Pike and Monroe Counties, Pennsylvania pp.234-241 and John B. White, American Locomotives Baltimore:John Hopkins University Press,1968 pp. 242-247.

[19]See White, American Locomotives pp. 239 - 247 for a discussion of the historical significance of the "Stourbridge Lion".

[20]The operations of the Canal is discussed in "Delaware and Hudson Canal Company vs. Pennsylvania Coal Company" volume I p. 142, volumne II pp. 659-664; 674; 677-681. See also LeRoy, Delaware and Hudson Canal pp. 78, 84-89.

[21]Robert J. McClellan, The Delaware Canal: A Picture Story New Brunswick, New Jersey:Rutgers University Press, 1967. p. 98.

[22]See "Delaware and Hudson Canal vs. Pennsylvania Coal Company" volumne I pp. 181-182 for the dimensions of both the old and new locks. The operations of the locks and lock gates are described in "Delaware and Hudson Canal vs. Pennsylvania Coal Company"volumne I pp. 143, 189, 221-222. See also Harlow Old Towpaths p. 396; LeRoy, Delaware and Hudson Canal pp. 22, 68, 80-82 and Dorothy Hurlbut Sanderson The Delaware and Hudson Canalway: Carrying Coal to Rondout Ellenville, New York: The Rondout Valley Publishing Company, second

edition, 1974 pp. 31-35.

[23]See LeRoy, Delaware and Hudson Canal p. 80 and Sanderson, The Delaware and Hudson Canalway p. 32 for descriptions of how locktend controlled the water level in Canal channel below and above the locks.

[24]For reprints of the "Rules for the Government of Lock-Tenders on the Delaware & Hudson Canal, 1882" and "Rules for Navigating the D & H Canal" can be found in LeRoy, Delaware and Hudson Canal pp. 81 and 84-89. For discussions of the composition of the boats' crew see "Delaware and Hudson Canal Company vs. Pennsylvania Coal Company" volumne II pp. 1073-1076.

[25]See for example, "Annual Report...for the Year" 1831 p. 14; 1835 p. 9; 1856 p. 6 for statistics on goods transported down the Canal.

[26]"Delaware and Hudson Canal Company vs. Pennsylvania Coal Company" volumne II p. 822.

[27]For samples of the boat operator contracts see "Delaware and Hudson Canal Company vs. Pennsylvania Coal Company" volumne II pp. 821-834; 868-874.

[28]Statistics on the delays caused by floods, breaches, etc can be found in "Delaware and Hudson Canal Company vs. Pennsylvania Coal Company" volumne II pp. 682- 686 and 695-697.

[29]See "Delaware and Hudson Canal Company vs. Pennsylvania Coal Company" volumne II pp. 700-707; 732-738 for procedures followed during emergencies and volumne II pp. 684-685 for delays during the 1853 navigation season.

[30]"Report of the Messrs, Benj. Wright and J.L. Sullivan..." pp. 1-22.

[31]The various efforts to develop anthracite grates by Jesse Fell and others is discussed in Century of Progress pp. 8-9; Frederick Moore Binder, "Pennsylvania Coal: An Historical Study of its Utilization to 1860", Ph.d. dissertation, University of Pennsylvania, 1955 pp. 7-30. Mathews, History of Wayne, Pike and Monroe Counties, Pennsylvania p. 226; and Wakefield Coal Boats to Tidewater p. 1 . See Century of Progress pp. 62-63 and Binder, "Pennsylvania Coal" p. 74 for the activities of the Delaware and Hudson Canal Company's coal agents. Further discussion of the Delaware and Hudson Canal Company 's efforts to increase the utilization of anthracite coal can be found in "Binder" pp. 134-141; 213-216 and

"Annual Report ... for the Year" 1834 p. 6; 1835 p. 7; and 1846 pp. 4-5.

[32]"Annual Report ... for the Year 1837" p. 10.

[33]"Annual Report ... for the Year 1838" p. 5.

[34]Accounts of the changes made in the Canal's dimensions during the various expansion programs can be found in "Delaware and Hudson Canal vs. Pennsylvania Coal Company" volumne I pp. 179-190; LeRoy pp. 119-145; Robert M. Vogel,"Delaware Aqueduct, 1848" A Report of the Mohawk-Hudson Area Survey Washington, DC:Smithsonian Institution Press, 1973 and Robert M. Vogel "Roebling's Delaware and Hudson Canal Aqueducts" Smithsonian Studies in History and Technology,number 10. Washington, DC:Smithsonian Institution Press,1971.

[35]For the technical details of the Aqueduct, Vogel's two essays, "Roebling's Delaware and Hudson Canal Aqueducts" and "Delaware Aqueduct, 1848" are ,most useful. For a good treatment of the innovations developed by Roebling throughout his engineering career, see D.B. Steinman, The Builders of the Bridge: The Story of John Roebling and His Son, New York:Harcourt, Brace and Company, 1945.

[36]Vogel, "Roebling's Delaware and Hudson Canal Aqueducts" pp. 6-9.

[37]For discussions of the design and construction of the cables see Vogel,"Roebling's Delaware and Hudson Canal Aqueducts" pp. 10, 15-16; Steinman The Builders of the Bridge pp. 80-81; and James Fitch, American Building: The Historical Forces that Shaped It, New York: Schocken Books, 1966 pp. 156-158.

[38]See Vogel, "Roebling's Delaware and Hudson Canal Aqueducts" p. 185 and Steinman, The Builders of the Bridge p. 87 for descriptions of Roebling's anchorage system.

[39]"Annual Report ... for the Year 1970" p. 3.

[40]A rather detailed and extended account of why and how the Canal Company shifted its system of transportation from the Canal to railroads is given in Century of Progress pp. 194-147.

[41]"Annual Report ... for the Year 1869" p. 4.

[42]See for example, "Annual Report ... for the Year" 1870-1876, 1881-1882, 1887, 1890 and 1899.

[43]"Annual Report ... for the Year 1898" p.3.

[44]Century of Progress p. 219.

[45]For accounts of the last years of the Canal see Century of Progress pp. 194-318, Sanderson The Delaware and Hudson Canalway,pp.63-71 and Wakefield Coal Boats to Tidewater pp. 197-202.