

SOME ENGINEERING FEATURES OF THE OLD NORTHAMPTON CANAL*

*By Charles Rufus Harte,† Member The Connecticut Society of Civil Engineers;
Engineer, The Connecticut Company, New Haven, Connecticut.*

The story of the Northampton Canal is a very important, albeit unwritten, chapter in the history of transportation in New England. The source material, however, apparently is very scanty and widely scattered; this seems particularly true of that phase with which this Society is particularly interested, the engineering. In the following pages is the result of an effort to assemble some of the engineering facts, with an introductory outline of the history of the project, as a necessary background; this limitation accounts for the omission of reference to James Hillhouse, Joseph Sheffield and others whose parts were not in the engineering field.

ACKNOWLEDGMENTS.

Only through the courtesy and assistance of a large number of persons has it been possible to secure access to some of the records, and the author is particularly indebted to The Connecticut Historical Society; Mr. Fred E. Dayton; Professor Henry W. Farnam; The Forbes Library, Northampton; Miss Frances Fowler; Mr. George S. Godard; Professor R. S. Kirby; The New Haven Colony Historical Society; The New Haven Public Library; The New York, New Haven and Hartford Railroad Company; Mr. Russell C. Parsons; The Sterling Library, Yale University; The Village Library, Farmington; and the Yale Art School, and both Society and author are much indebted to the New Haven *Register* for the loan of the majority of the cuts used.

BRIEF OUTLINE OF PROJECT.

The Northampton Canal was one of a number of similar canal projects, which, while of great benefit to the communities they served, were sorry investments for the early stockholders. Unlike many of those other projects, however, it was a wisely conceived scheme to meet a real need; there was every reason to anticipate a successful and profitable outcome, and the failure to realize the expected result was caused by a combination of adverse circumstances which could not have been reasonably foreseen.

Projected to give to the important traffic with the upper Connecticut

* Presented at Forty-ninth Annual Meeting, Hartford, February 21, 1933.

† By the same contributor.

"Public Utility Valuation," Proc. 1923.

"A Modern Power Network," Proc. 1913.

"Boston-Providence R. R. Ex.," Proc. 1905.

Valley a safe and easy route to and from tidewater in place of the passage on the Connecticut River with the difficulties and dangers at Hadley Falls and the Enfield Rapids, and at the same time to furnish better means of transportation between the communities on the route, a company called the "President, Directors and Company of the Farmington Canal" was chartered at the May, 1822, Session of the Connecticut Legislature to construct and operate a canal from New Haven through Farmington to the Massachusetts boundary at Southwick, together with a branch up the Farmington Valley from Farmington through New Hartford to the Massachusetts boundary in Colebrook, looking to an eventual connection with the Erie Canal.

The next year Massachusetts chartered the "Hampshire and Hampden Canal Company" to continue the main line from Southwick to the Connecticut River just above Northampton. Considerably later Massachusetts, Vermont and New Hampshire granted rights to continue north to the Canadian border, where a Canadian group was prepared to build the last section. Had this been done there would have resulted an international waterway from Long Island Sound to the St. Lawrence River. As a matter of fact, however, although steamboat lines were operated on the upper river in connection with it, the canal never was extended above Northampton, nor was the New Hartford branch constructed.

The two original companies were in financial difficulties from the start. Subscriptions to the stock were slow and many of the subscribers failed to pay as the instalments came due, while unprecedented floods and droughts and malicious injuries caused heavy losses both during and after construction. The canal did a good business from the beginning, but both sections were subject to such extraordinary expenses that by 1836 they were hopelessly in debt. As the only means of saving anything a new organization, the "New Haven and Northampton Company" was chartered that year in both Connecticut and Massachusetts to take over the assets and liabilities of the original companies. The old stock was surrendered by the stockholders and the debts were adjusted as best could be done, with a loss to all concerned of roundly \$1,039,000.00.

Although the new company did a large and growing business when it was in operation, the extraordinary expenses and interruptions continued, and to these troubles was added the threat of railroad competition. Realizing that the railroad was the coming means of transportation, an amendment to the charter permitting the change was obtained, and in January, 1847, work was begun on a railroad which reached Plainville in January of the next year, and while the section of the canal north of this point was kept open for some time longer, canal operation may be said to have ceased with

the close of the season of 1847. It has been estimated that, giving due credit for the saving to the railroad by use of canal property, and for the land not so used in the City of New Haven, the total loss chargeable against the canal project was \$1,089,425.10.

Discussion of the possibility of building the canal was begun at least as early as 1819, but it was January 29, 1822, before definite steps were taken to determine whether or no it would be practicable to construct the waterway, and if practicable if there would be available the necessary water supply at the required elevation. On that date representatives of some seventeen interested communities met at Farmington and authorized a committee to spend one thousand dollars for the necessary investigation.



FIG. 1. BENJAMIN WRIGHT, CONSULTING ENGINEER

The committee very wisely secured the services of Benjamin Wright, then the Chief Engineer of the Erie Canal, and generally considered the leading American canal engineer of the time. Born at Wethersfield, Connecticut, in 1770, he had had a typical farm-boy's education until he was fifteen; then, after three years spent reading law and studying and practising land surveying at his uncle's in Plymouth, Connecticut, he had gone to Fort Stanwix, New York State (now a part of Rome), which then was "out in the far west." Here he made a great reputation as a land surveyor, served a brief term as a county judge, getting the title by which thereafter

he was generally called, and then, becoming interested in canals, his ability and ingenuity had eventually gained him the chief engineership of the Erie Canal. By securing his services the committee was assured both of the best available technical advice and, because of his reputation, of the confidence of the general public in his report.

SURVEY.

To take the necessary levels Judge Wright employed Eli Whitney Blake, later to become famous, on the one hand, as the inventor of the jaw type stone crusher, on the other, as a great mathematician. The levelling instrument Blake used was one "prepared" by his uncle, Eli Whitney, inventor of the cotton-gin, and a manuscript note in the possession of the New Haven Colony Historical Society would indicate that the levels were taken in feet, inches, and tenths of an inch.

To the committee Judge Wright reported:—

"The result of this examination is a decided opinion that the country is favorably formed for a great work of this kind."

"Comparing the quality of the soil, the convenience of stone for masonry, and the other localities through the route proposed, I think a canal may be formed for a considerable less average expense per mile, than the cost of the canals now making in the state of New York."

And he concluded, in the approved style of the time:—

"Permit me, gentlemen, to express a strong desire to see this first project of the kind in Connecticut carried into effect, and be but the incipient step to works of internal improvement that will be a lasting monument of the enterprise and intelligence of a high-minded people.

"Respectfully, Gentlemen,

"Your obedient Servant,

"BENJ. WRIGHT."

COST.

In view of the quite general belief that the Northampton was a very costly canal it is of interest to try to check Wright's snap judgment with the actual cost, and the latter with that of some of the other canals. The loss at the time of the merger, in 1836, undoubtedly represented much more money than had gone into construction alone, but if we consider it the "original cost" the average per mile was \$13,321.00. Sweet, in his "Documentary History of the New York State Canals" gives the average of all the early New York canals as \$17,367.57, and that for all New England as \$12,838.71, the latter being the only figure lower than that for the Northampton, while Harlow, in his "Old Tow Paths" gives the per mile cost of the Chesapeake and Delaware at \$155,000.00!

DETAILED SURVEY AND REPORT.

Judge Wright's first investigation was but little more than a reconnaissance to develop the question of the practicability of the canal in Connecticut, and in view of the complete dependence of each section upon the other it did not seem advisable to take any further steps until the Massachusetts situation was determined. The grant of a charter in that state cleared the way, and August 21, 1823, Judge Wright started a detailed survey of the Connecticut section, with his son Henry Wright in charge in the field. The latter made a report in considerable detail as to physical conditions and construction quantities, but with the exception of "Grubbing" and a few instances where there were boulders to move, made no attempt at pricing. Judge Wright, referring to Henry Wright's report for other details, gave only quantities, which he then priced, extended, and totaled. The estimate was treated in mile long sections, but apparently for contract purposes these later were halved. The report on "Mile 21st" (the numbering being from Massachusetts line south) which is the section containing the big aqueduct over the Farmington River, is, capitals and all, as follows:—

"Mile 21st. From its commencement for 24 Chains is carried along side-lying ground of moderate declivity. At this point the two routes in the vicinity of Farmington and which may be designated as the Eastern and Western routes will diverge—the Eastern crossing Farmington River by an Embankment and Aqueduct and passing through Farmington Village—the Western passing by a Dam at about 3 miles distant—Both routes have been surveyed by the direction of the Board of Commissioners, and an estimate of both, together with a rough draft which will exhibit their general course, is herewith submitted.

The East as being the route originally contemplated will be first presented—From the point mentioned the ground rises gradually in 12 Chs to an elevation of 25 feet above the level, but in 5 Chains it will descend again to bottom, where a lock of 10 feet is located, and the Embankment across the Valley of Farmington River will then commence—From this point to the W. Bank of the River the distance is 7 Chains and the Embankment will average 13 44/100 below the Level—The earth for the Embankment can be advantageously obtained from the hill through which the canal is carried, the soil of which consists of sand and light gravel—An aqueduct of 200 feet in length, consisting of stone abutments and piers supporting a wooden Trunk (a plan of which is herewith submitted) will then be required across the Farmington River. From the Eastern extremity of the aqueduct to the commencement of the ascent on the E. side, the distance is 6½ Chains and the Embankment will average 16 75/100 below the Level and 1½ Chains further it will end. On the E. side the material can not be obtained so advantageously and the soil is not so easy of excavation.—For the residue of the distance of gentle declivity, but which presents some irregularities of surface and several chains of hard stony excavation."

The quantities for this mile as given by Henry Wright, with the prices and extensions by Judge Wright are as follows:—

17,925 yds. Excavation (W. side easy) @ 7c.....	\$1,254.75
8,213 " Do (E. side hard) 10c.....	821.30
26,606 " Embankment (W. side) 14c.....	3,724.84
32,349 " Do (E. side) 16c.....	5,175.84
Aqueduct over Farmington River.....	10,000.00
1 Road & 1 Farm Bridge.....	250.00
Grubbing (priced by Henry Wright, C.R.H.).....	100.00
	<hr/>
	\$21,316.73

At some later date it was decided to raise the aqueduct, lengthening it to 280 feet, and do away with the lock of this section. This change resulted in one continuous level from Granby to Southington.

Judge Wright's summation of the estimate figures, a total of \$420,698.88, is almost invariably given in accounts of the canal without his highly important and significant statement immediately following his total; "Damages for Lands, Houses, &c., to be added."

REPORT.

The report was presented at a stockholders' meeting held April 22, 1825, and the recommendation of the Directors that work be started as soon as practicable, was adopted. Whether an attempt was made to secure one of the Wrights as Chief Engineer does not appear; at all events Mr. Davis Hurd was employed as Chief, and his brother Jarvis as Assistant.

DAVIS HURD, born April 12, 1788, at Arlington, Vermont, like Benjamin Wright was a farmer's boy, and had only a country school education. When he was twenty-three he moved to Scipioville, New York, and for three years with his brother Marshall had a shoemaking shop, then, shop and stock having been destroyed by fire, he turned to civil engineering and in 1820 was appointed Resident Engineer on the Erie Canal with headquarters at Lockport. It seems probable that Judge Wright, his superior, recommended him to the Farmington Company. Of Jarvis the History and Genealogy of the Hurd family states he was born February 15, 1800, at Arlington, Vermont, and that he was "a successful lumber merchant." His brothers, Davis, Erastus and Isaac, are mentioned as "accomplished civil engineers," but of Jarvis' engineering experience there seems to be no record other than in the canal papers. He must, however, had had some earlier reputation, for he was entrusted with making the locations and estimates of both the section of the Hampshire and Hampden Canal that was built, that from the Connecticut border to Northampton, and of the proposed extension as far as Brattleboro, Vermont.

The records of the early engineering on the Hampshire and Hampden are not clear. Henry Wright made the preliminary survey on which was

based the application for the charter, but other than that he began it October 10, 1822, and that it was quite "thorough and particular", there has been found no record of it. The charter was granted February 4, 1823, but subscriptions to the stock came in very slowly, a fact which probably accounts for the vote of the Stockholders of the Farmington Company at the annual meeting on January 7, 1824, authorizing the Directors to cause an examination to be made of the route of "the contemplated canal between the north line of this state and the Connecticut River at Northampton, with a particular estimate of the expense thereof, and to report at a future meeting of the stockholders."

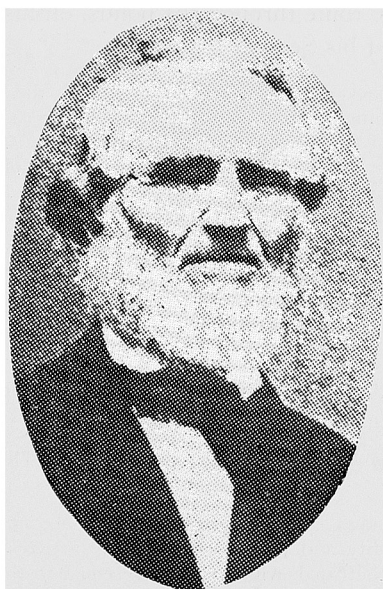


FIG. 2. DAVIS HURD, CHIEF ENGINEER IN 1825.

There is no record of such report, but the *New Haven Register* of February 4, 1826, states that the survey from the Connecticut line to Northampton was completed on "Friday of last week" (presumably January 29th) and as of April 3 of that year Jarvis Hurd, then apparently employed by the Hampshire and Hampden Canal Company, made a detailed report of the location and estimate to Messrs. Thomas Shepherd, Elijah Bates, Augustus Collins and John Mills, the Executive Committee of that company.

The facts are set up in the same general form used by the Wrights in their report on the Farmington Canal. Unlike the latter report, however, which appeared only on the company records, the Hurd report and estimate

was printed as a pamphlet and distributed and there are at least several copies in existence.

Hurd divides his route into sections "most of which are 42 chains," and did his own pricing. His figures were based on going west of the Congamond Ponds and dropping to the level of Westfield by seventy-eight feet of double lockage, but he suggests the desirability of further investigation with a view to a possible shift to the east and the use of the ponds as part of the canal. Later, Davis Hurd having been "authorized to leave the service of the company to lay out the Hampshire and Hampden Canal from its southern extremity to Westfield," a joint committee of the two companies decided on the route through the ponds, on his recommendation.

Jarvis Hurd says of his Section XIX:

Passes along just back of, and nearly parallel with the principal street, in the beautiful and flourishing village of Westfield. It has a very eligible location for the convenience of the town, and will furnish one or two fine natural basins, at points that will best accommodate the business of the place. It has from two to six feet depth of cutting. The soil is sandy loam. It has:—

13,690 cubic y'ds of excavation at 4 cts.....	\$547.60
1 road bridge	85.00
1 farm bridge	60.00
Grubbing and clearing	10.00
	<hr/>
	\$702.60

His total of \$290,000 makes no mention of land damages, nor is there anything regarding such expenses anywhere in his report.

Jarvis was in no ways behind Wright in Victorian English. He concludes:—

This result, Gentlemen, not only shows the amount of the probable expense, but the quality, quantity and prices, of the many articles to be removed on, or used in constructing the canal, which prices are equal to the object to be affected, and with strict economy in the charge of its construction, I think must fall within the amount. My entire confidence in the scheme, need not be mentioned; nor that I retain the most sanguine opinion of its utility and productiveness, which are based upon never failing principles. But confident as I am, Gentlemen, of the great importance of so valuable a work, and the flattering prospects of profit from an ever-increasing revenue, I wish you all the success, so laudable an undertaking merits, and hope for its speedy completion, and shall ever be happy in rendering you any service hereafter, that shall tend to further the project, which health will permit.

Respectfully yours, &c.,

JARVIS HURD.

Northampton, April 3, 1826.

The two estimates, shown in some detail in the comparative table, are particularly interesting for the elaborate classification of excavation and embankment, and the low prices.

WORK STARTS.

Work on the Farmington Canal was formally begun on July 4th, 1825, when "two or three thousand people, among them several gentlemen of distinction from Massachusetts," after a prayer, a reading of the Declaration of Independence and an "able oration" marched, in a procession two miles



FIG. 3. SECTION OF CANAL NEAR GRANBY, CONNECTICUT.

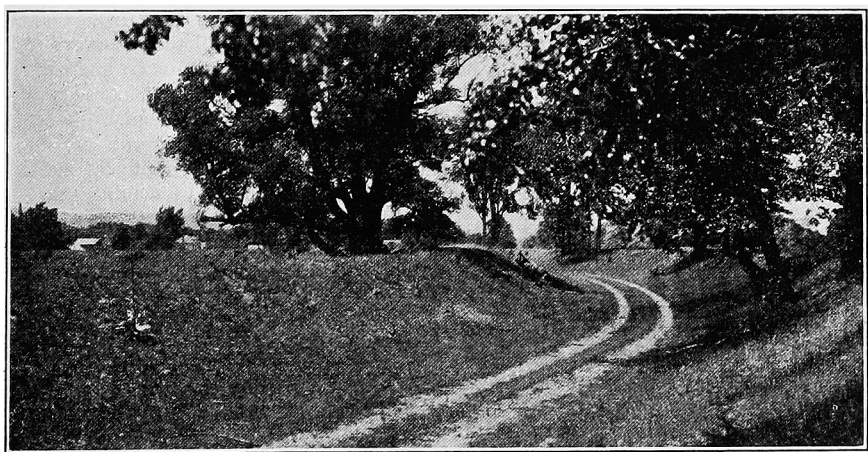


FIG. 4. CANAL AT TEN MILE RIVER, MILLDALE, CONNECTICUT.

long to the north line of the state, where Governor Oliver Wolcott, of Connecticut, after an address, turned the first sod, and, incidentally, broke the spade. Another address, the parade back, and a dinner to the invited

guests under what Deacon Hooker of Farmington called a "bouerie" on Granby Green ended the ceremony.

Massachusetts evidently considered this her official opening also, although there was a little celebration at Southwick, when on November 1, 1826, Sheldon and Hurd began actual work on the Hampshire and Hampden Canal.

In Connecticut the work was let out to a number of contractors, the more important masonry structures apparently being let individually. The first award was on August 5, 1825, and by December 5 of that year contracts had been made for the Farmington River aqueduct, all the culverts, and all other work beginning with Section No. 1 at the Massachusetts line through No. 68 in Cheshire.

In Massachusetts there were but two contracts, one with Sheldon and Hurd, from the Connecticut line to the Westfield River, later taken over by Sheldon alone, and the other with Thomas Shepherd, from the south side of the Westfield River to the Connecticut River above Northampton. As yet, no details of any of the Connecticut contracts have come to light, but the original Massachusetts contracts are in existence. They both are lump sum agreements, the price being for the section complete, including also:—

"All damages which shall be assessed on the whole of said canal from the north line of Connecticut, to the entrance of the same into the Connecticut River in Northampton in the County of Hampshire in the State of Massachusetts for lands, mills, water privileges and for every other injury which may arise from the making and constructing said canal, and the necessary feeders, all the compensation or wages of Superintendent, President and Directors and engineers, and all others necessarily employed in the business of said canal, all the preliminary expenses which have been incurred by said Hampshire & Hampden Canal Company in the survey of said Canal or otherwise, all the necessary alterations in public or private ways, all Waste Weirs and Fences and all other contingent and incidental expenses which may in any way accrue in the business of making said canal."

Sheldon and Hurd were to receive 731 shares of stock and \$138,968.52, while Shepherd, who had no obligations as to damages, etc., was to receive 269 shares and \$51,030.48. Each contract has attached two exhibits, one being a printed specification sheet used on the Farmington Canal, with the word "Farmington" scratched out, and "Hampshire and Hampden" written in; the other a pen and ink sketch with long-hand bills of material for road bridges, 42 feet long, 14 feet wide, and having truss timbers 8" x 10", and for farm bridges, 42 feet long, 12 feet wide, and having truss timbers 7" x 9". The contract refers to lock and aqueduct plans drawn for the Farmington Canal by Davis Hurd, and deposited with the Hampden Bank of Westfield "for safe keeping and for the use of each party," but although

President Little of the successor "Hampden National Bank and Trust Company," who was greatly interested, had a careful search made, no trace or record of the plans could be found.

A number of the contractors failed, necessitating reletting their sections. At first thought it might well be questioned if the apparently low prices were not the chief cause of the trouble, but the fact that in each case of default the Directors authorized the reletting only on condition the original prices were not exceeded, and that in no case is there record of any difficulty on this score, would seem to indicate some other reason.

There were two factors which undoubtedly played important parts. All contracts were let on the basis of the contractor accepting in payment as much stock as possible, but practically nothing could be realized on this in the market. When the company had funds it made various advances to the contractors, but much of the time it was hard put to meet its own obligations, including the cash payments to the contractors, so that those of the latter who had not reserve funds to fall back on were in a bad way.

The other important element was the fact that many of the contractors had had little or no experience with work of any extent. The Erie Canal was almost the only large project up to this time, and while some of the contractors on the Farmington Canal came from the work on the Erie others were local men entirely unaccustomed to work more extensive than the excavation of a large cellar.

CANAL DESIGN.

The canal section was fixed at a bottom width of 20 feet, a width at water surface of from 34 to 36 feet, and a depth of water of 4 feet, the towing path and the berm bank or opposite side to be not less than two feet above the water surface, nor, in the case of the towing path, more than 5 feet above. In cuts a shelf was made for the towing path, which in all cases was at least 10 feet wide. In the Congamond Ponds the towing path was carried as a fill across some of the shallow sections; where the water was deep close to the shore the natural bank was benched; while across one stretch of 700 feet there was anchored a floating towing path which had been built on shore, launched, and towed about a mile to its destination. Later this possible mobility was taken advantage of by some enemy or enemies of the canal, and on at least one occasion it was cut loose and allowed to drift away, luckily without receiving serious damage.

As will be seen by the specifications—Appendix A—the treatment of the earthwork was in accordance with the best practice of today except as to the employment of rolled layers, and it is quite probable that few if any of the contractors had ever seen a roller of any size. It is questionable, how-

ever, if the work was done quite as thoroughly as the specifications demanded; the frequency of breaches of the canal banks seem to indicate a disregard of some of the requirements.

WATER SUPPLY.

Next to maintaining the integrity of the canal banks came the question of water; how to get enough, and how to guard against too much. The Connecticut canal was fortunate in the relation of the Farmington River. A dam just below Unionville, and three miles of a feeder canal—which, incidentally, would have been a part of the New Hartford canal, had that “side cut” as it was termed, been built—delivered what was supposed would be an abundance of water to what was almost the highest level. Losses through the soil, particularly that of the Hamden Plains, as well as evaporation, however, necessitated additional supplies, and all along the line such brooks as were at the proper elevation were led into the canal, while from time to time spillways were built to take off any excess due to rain. Failure to realize the amount of water which would have to be so wasted led to some bad washouts, the over-full canal spilling over its banks, until the necessary additional spillways and waste gates were provided.

The short summit level at the Connecticut-Massachusetts boundary was first fed from the Congamond Ponds, but the possibilities of this supply had been over-estimated, and there was trouble over water rights, eventually leading to a feeder from the upper water of Salmon Brook.

In Massachusetts, the Congamond Ponds fed the flight of locks leading down into the Westfield Valley; the valley level itself had a feeder from Little River; while a large feeder from Westfield River, taken off from above the falls at Woronoco, and carried six miles across country, fed the summit north of Westfield and the levels from there down to the Connecticut River.

STRUCTURES

The canal was taken over such brooks as were too low to be led into it. In Connecticut, with the exception of the Farmington River and Mill River crossings, this was done by stone arch culverts, a number of which exist today in various conditions. All are of the same general type; except where on a rock foundation there is a plank floor which extends under and carries the side walls, and which, unless the engineer deemed it unnecessary, is “protected” by piling at each end. The side walls, which are about two feet high regardless of span, and the semi-cylindrical barrel are of rubble, usually laid in “water lime,” or natural cement, as are also the headwalls, the ends of which are curved. The ring stones are cut, but are fre-

quently of varying sizes in the same ring, and in some instances there not only is no key stone, but the nearest stone to that position is one side of it.

These culverts range in span from four feet up to the beautiful forty-



FIG. 5. TYPICAL STONE CULVERT UNDER CANAL.

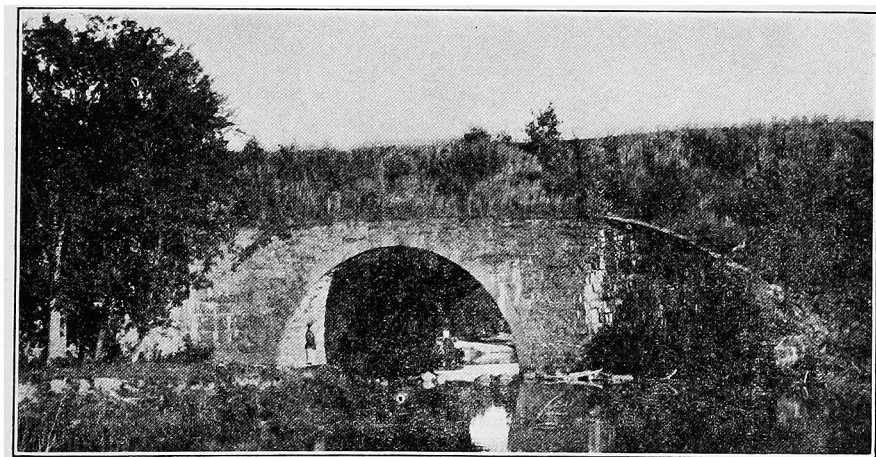


FIG. 6. ARCH CARRYING CANAL OVER SALMON BROOK, GRANBY, CONNECTICUT.

feet span arch over Salmon Brook at Granby, particularly interesting as being the third attempt to span this brook, the two first ones having been washed away by floods. No information has been found as to the first

other than it was wrecked before August 31, 1826, for on that date the Superintendent and the Engineer were instructed to determine whether to rebuild or to substitute an aqueduct. The bids for rebuilding were asked for on September 16; the culvert was to be of forty feet span, of stone laid in water lime, and the price per perch ($24\frac{3}{4}$ cubic feet) of masonry was to include laying "and securing" the foundation, which was to be of stone or timber at the option of the Engineer.

Whatever was done, the culvert went out again in the flood of September 4, 1828, but presumably on October 3, 1829, it was reported completed. The third time evidently was "the charm" for it is today carrying the tracks of the Northampton branch of the New York, New Haven and Hartford Railroad.

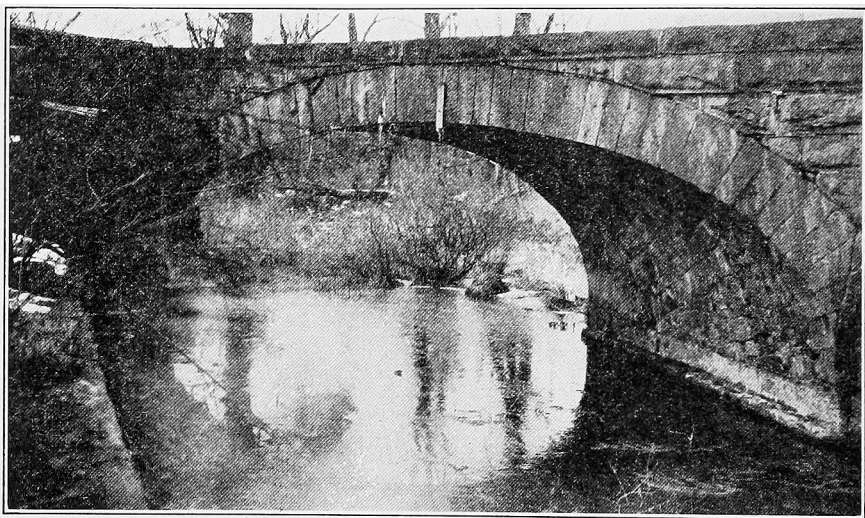


FIG. 7. SKEW ARCH CARRYING RAILROAD OVER CANAL NEAR BROOKSVALE, CONN.

In Massachusetts the majority of the culverts are gone, a very short section of what was a very long twelve-foot span arch culvert which carried the upper level feeder from Westfield River over Moose Meadow Brook, near Woronoco, being the only example of arch culvert remaining. Near Northampton, there are several box culverts under the Northampton branch at points where the latter now occupies the site of the canal, but while it is probable these were built for the canal, this is open to question.

There is in Connecticut an arch culvert which, while not built as a part of the canal, was constructed to permit the canal to operate while the railroad operated over it. Located near Brooksvalle—it is Bridge 13.00,

that is, 13 miles from New Haven station, on the Northampton branch—it is a multicentered helicoidal skew arch. The arch consists of a tangent 2 feet long on each side, next 6 feet of a 6 feet radius circle each side, and finally a central arc 12 feet long of 12 feet radius. The normal span is 18 feet, but the heavy skew angle gives an opening at the face of 28 feet. Its particularly interesting feature however is in the development of barrel beds to be approximately normal to the theoretical pressure lines, these beds starting horizontally and then curving down to make an angle of approximately 30° with the horizontal.

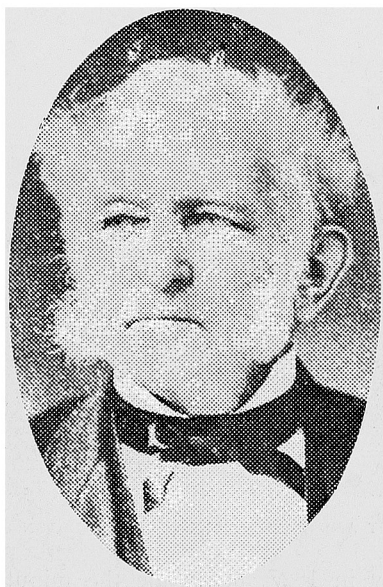


FIG. 8. HENRY FARNAM, ASSISTANT AND LATER CHIEF ENGINEER.

This was the work of Henry Farnam, who succeeded Davis Hurd as Chief Engineer about 1828. Another farm-boy, Henry Farnam was born at Scipio, New York on November 9, 1803 and had much the same type of education as Benjamin Wright and Davis Hurd, the latter being a relative by marriage. In 1821, through Davis Hurd's assistance, he was taken on the surveying party of David Thomas, then Chief Engineer of the Erie Canal west of Rochester. Starting in as cook, the only position vacant, he soon had opportunity to show his ability and was rapidly advanced. Davis Hurd brought him to the Farmington Canal as his second assistant, at the princely salary of one dollar a day and expenses, Hurd as Chief Engineer receiving at that time \$2000 a year and expenses.

Just when Henry Farnam became Chief Engineer is not clear. Davis Hurd was Chief Engineer of both companies as of September 30, 1826, for the contracts for the construction of the Hampshire and Hampden Canal, of that date, say:

"And it is further agreed by the parties that Davis Hurd Esquire shall be the chief engineer on said canal etc. etc."

His resignation, "at least until the next spring" was accepted November 19, 1829, and Wm. H. Butler was temporarily employed in his place. Farnam's biographies say he became Chief Engineer of the

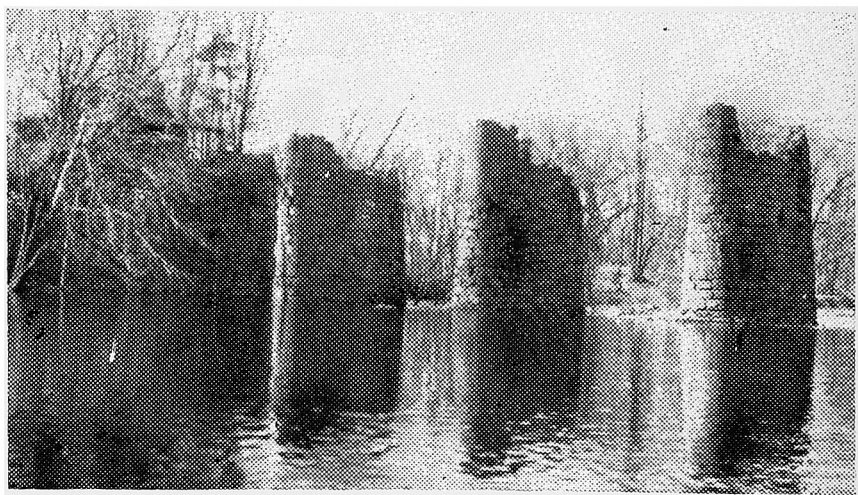


FIG. 9. ABUTMENT AND THREE PIERS OF FARMINGTON RIVER AQUEDUCT.

Farmington Company in 1827, but while the minutes of that company from 1826 record increasing responsibilities rested on him, and refer repeatedly to the "Chief Engineer", there is nothing to show who the latter was, and some of the 1828 references are of a character to at least make it a question if it was Farnam. In any event, soon after Davis Hurd's resignation from the Hampshire and Hampden Company Henry Farnam became Chief Engineer, first of both companies, and then of the successor company, the New Haven and Northampton Company, from which he resigned in 1850, at which time the Directors, in resolutions of appreciation, said:

"For the uniform fidelity with which Mr. Farnam has performed all the duties devolving upon him; for the unimpeachable integrity with which the many thousand dollars, which have passed through his hands, have been expended; for the unshaken confidence with which he carried forward

these works under very great difficulties; and for the heavy personal responsibility which he often assumed to maintain the works, when otherwise they would have been sacrificed, this Company entertain the highest consideration."

Just how much Henry Farnam had to do with the early construction is not clear, but it was he who successfully repaired all the breaches and other difficulties of its later years.

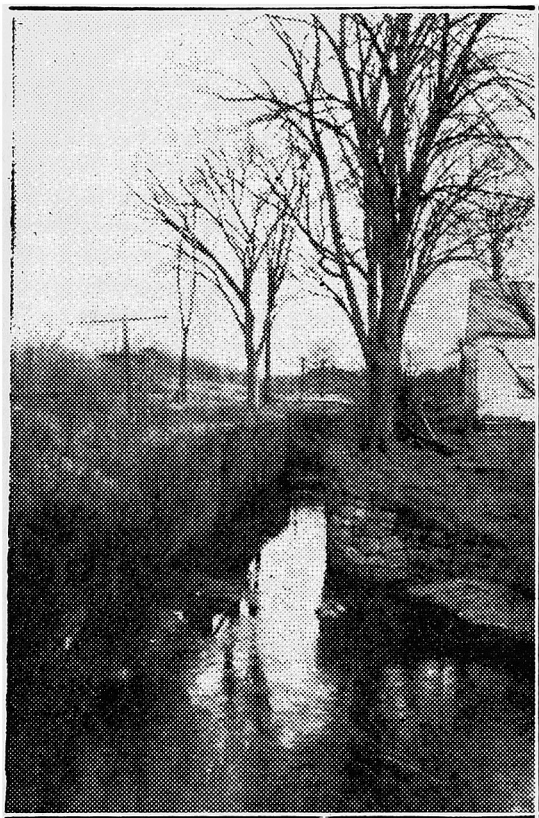


FIG. 10. LOCK NO. 12 NEAR BROOKSVILLE, CONNECTICUT

Connecticut used one, and possibly two aqueducts to get the canal over streams. The Wright estimate lists one 20 feet long over Mill River in a single span. The one as to the construction of which there is no question crossed the Farmington River by seven spans of 40 feet each; three of the six piers are still standing, in fair condition, as is the north abutment; the three other piers and the south abutment were taken down

to the ground level for the stone in them. Striking as the structure must have been, not only are there in evidence no plans or sketches, but no one seems to remember how it looked, although Professor Henry W. Farnam, son of Henry Farnam, remembers as a small boy crossing the river on it in company with his father, in 1863. Undoubtedly it consisted of a wooden trough at least 12 feet wide and 5 or 6 feet deep, carried by some form of truss, either along side or above the box, with a towing path on one or both sides of the trough, but even the masonry fails to show any clear indication as to how the trusses were seated.

In Massachusetts, possibly because of more limited headroom, there were six aqueducts ranging in length from 30 feet to 300 feet, but there

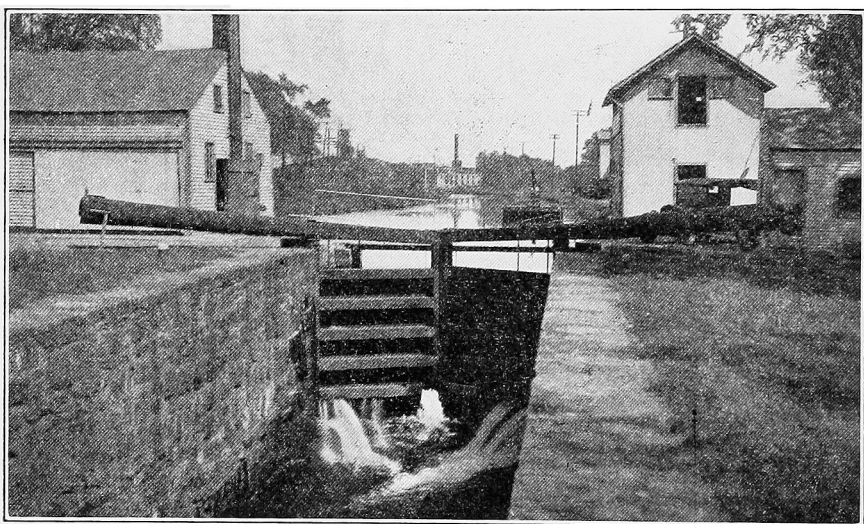


FIG. 11. TYPE OF LOCK USED ON NORTHAMPTON CANAL.

is even less information regarding these than there is of the Connecticut ones, for the Massachusetts masonry either is entirely gone or is so built into other masonry as to have its original appearance entirely concealed.

One other structure remains to be considered. As the canal was located, to reach the Connecticut River at the "Honey Pot Bend" above Northampton, it was necessary first to rise 220 feet to the Congamond Ponds, which was done by means of 28 locks; from the Congamond Ponds to the Westfield Valley there was a drop of 79 feet, by means of 9 locks; it was then necessary to climb out of the valley, 90 feet, by means of 9 more locks; and finally by 14 locks, to drop again 134 feet to the river.

An excellent idea of the appearance of these locks can be had at

Windsor Locks (Fig. 11), where there are in service today locks built originally about 1828, and which have been repaired in kind so that today they are practically the same as when first built. They differ from some of the Farmington and Hampshire and Hampden locks, however, in the fact that they are masonry walled locks, while some of the Northampton Canal locks had stone side walls which were laid dry and served merely as retaining walls. A series of headers were left projecting 14 inches, and against these came the posts of the wooden lining, the space serving to catch any earth and keep it from piling up against the lining

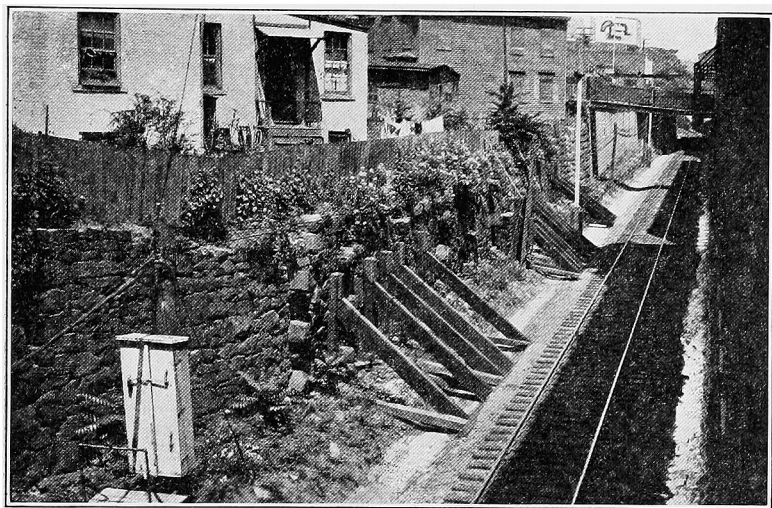


FIG. 12. WEST WALL OF LOCK NO. 27, NEW HAVEN, CONNECTICUT.
(BETWEEN ORANGE AND WALL STREETS.)

to cause decay. The walls were spaced apart the proper distance to give a clear width of the wooden lining of 12 feet, with a length of 80 feet in the clear.

At a later date a change to all-masonry was made. Most of the locks have gone entirely but enough wall remains to show that Connecticut Lock No. 12 (Fig. 10) was all-masonry; and Nos. 10, 11, 13, 14, and 27 (Fig. 12) were wood lined when operation ceased. In Massachusetts there are but two locks of which any appreciable amount of wall remains. No. 9 was wood lined; No. 22 all-masonry. The wood lined lock had proved quite satisfactory on the Middlesex Canal, and cost but $\frac{1}{3}$ as much as the all masonry type, but apparently its behavior on the Northampton Canal was unsatisfactory, for the later built locks were chiefly all-masonry.

THE CANAL COMMISSION.

There is a very interesting feature of the Farmington Canal which in part comes under the head of "engineering features." As early as 1797 Connecticut began the practice of establishing a commission for each of its public utility corporations. In some instances their duties were very light, but the "Commissioners for the Farmington Canal" had very extensive duties and powers. They were required not to be "interested in any way whatever" in the corporation, and were sworn to a faithful discharge of their trust. With the assistance of such engineers,

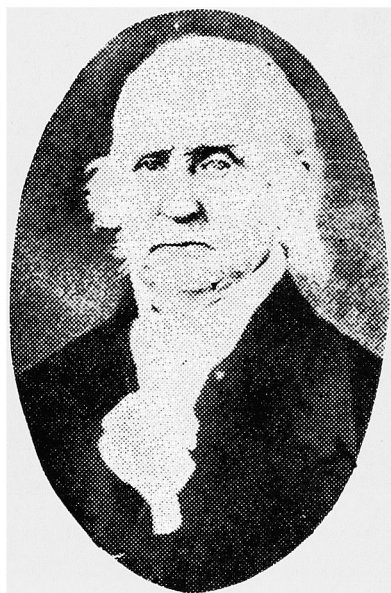


FIG. 13. SIMEON BALDWIN, CHAIRMAN OF THE CANAL COMMISSION.

surveyors and other agents as the corporation might employ, they were to survey and lay out the canal, fix the widths of land takings and determine benefits and damages, the owner having right of appeal to the county court, the decision of which, however, was final; they were to determine the location and dimensions of bridges over the canal and the location of toll houses; they were to open the subscription books, determine the amount of the capital, and warn and call the first meeting of the stockholders. Theirs was the power, annually to license as many boats and at such fees as they deemed expedient, and to fix the toll on the boats and on the articles carried; they were to report the cost of the canal, when finished, to the comptroller of the state, to pass upon the

proposed relocation of any highway, and if approved, to see that it was left in as good repair as before; to make and file with the Secretary of State a report on their survey of the canal location as soon as the canal was completed, and to inspect from time to time the construction, and annually and if necessary oftener, inspect the canal, the bridges and the other works, with power to suspend the collection of tolls, if any order to correct any trouble was not complied with, until such correction was made.

The commission consisted of Messrs. Simeon Baldwin, chairman, Isaac Mills, William Moseley, George Cowles, Jonathan Pettibone Jun., and Roger Mills; they were to be paid "a reasonable compensation" which later was fixed at three dollars a day and expenses, with two dollars a day extra during the period of actual location in the field.

In an "Account of the Farmington Canal," prepared at the request of the President of the New Haven and Northampton Company and published in 1850, it was justly said:

Their duties were arduous, and the responsibilities which devolved upon them very great, but they executed the trust confided to them with scrupulous fidelity, as the carefully kept records of their proceedings will show. It is no more than mere justice to refer in a special manner to the services rendered by the President of the Board, the Hon. Simeon Baldwin, and the Secretary, Mr. William Moseley."

CLOSE.

In closing, the author would point out that the purpose of this paper is two-fold:—to bring together at least some of the known facts regarding the engineering features of the Northampton Canal, and to call attention to the great lack of information as to others. The members of this Society are earnestly urged to be on the lookout for any material relating to the canal, and if any such is found, to put it in the keeping of one of the Historical Societies, if not as a gift, at least as a loan.

APPENDIX A
SPECIFICATIONS
IN RELATION TO THE CONSTRUCTION, ETC., OF THE
FARMINGTON CANAL.

GRUBBING AND CLEARING, PREPARATORY TO EXCAVATION.—All the trees, logs, stumps, bushes, roots, and timber of every kind shall be dug, grubbed, cleared, eradicated and wholly removed from a space of 58 feet, viz: 29 feet on each side of the middle of the Canal; and on each side of the part so grubbed, the trees, bushes and timber shall be cut and removed in such manner as the Engineer shall direct.

EXCAVATION.—All the top soil, vegetable mould and every other substance of a porous or perishable nature, shall be first removed from the surface of the ground to be excavated, into the outer extremities of the banks; and wherever the earth to be excavated, at or below the top water-line, is composed of materials which are porous, perishable or permeable to water, such material shall be removed as aforesaid, not only from the surface of the ground to be excavated, but also from the base of the bank or banks where such materials are to be found, for the space of ten feet horizontally measured from the top water-line; and the bank or banks, in such cases, for the said space of ten feet horizontally measured from the top water-line, and also above and *below* the same, shall be wholly made and constructed of the most pure, solid, compact and water-tight earth, which can be procured from the adjoining excavation.

DIMENSION AND SLOPE OF THE CANAL.—The Canal shall be constructed in such manner, that the water may, in all places, be at least 20 feet wide at the bottom, and shall be 34 or 36 feet at the surface or top water-line, as the Superintendent or Engineer shall direct, and shall be four feet deep, reference being had to the levels, surveys and maps of Davis Hurd, Esq., Engineer.

TOWING PATH BANK.—The bank to be occupied for a towing path, shall, in all places, be at least ten feet wide, at its surface; it shall be smooth and even, without any sudden inequalities in its height, nor shall it in any place, be less than two, nor more than five feet perpendicular measurement above the top water-line; its surface shall be composed of the best materials for a towing-path, which the adjoining excavation can supply.

OPPOSITE BANK.—The bank opposite the towing-path shall be, at least, seven feet wide on its surface, and at least two feet perpendicular measurement above the top water-line.

SLOPE OF BANK.—The inner sides of the banks, as well above as below the top water-line, shall have such a slope, as that every foot perpendicular rise, shall give a horizontal base, of at least two feet; the outer sides of the banks shall have the same slope, unless otherwise directed by the Engineer.

DEEP CUTTING.—Wherever the top water-line will be more than five feet below the natural surface of the earth, the towing-path shall be ten feet wide, and not less than two feet, nor more than five feet perpendicular measurement above the top water-line, and on the opposite side of the canal, there shall be no horizontal basin or recess unless directed by the Engineer.

EMBANKMENTS.—The ground which is to be occupied as the base of an embankment, shall be effectually grubbed and cleaned, and all the trees, logs, stumps, roots and timber, and every other substance of a vegetable or perishable nature, shall be removed therefrom. The embankment shall be wholly composed of pure, solid, compact and water-tight earth, and shall have the form, slope, height and dimensions, heretofore specified, subject to the direction of the Engineer, as to the slope of the cut and outer banks, as before mentioned. No sticks, logs, roots or timber of any kind shall be left, laid, or admitted into, or under any bank or embankment.

SPOIL BANKS, RUBBISH, &c.—The Spoil banks or surplus earth shall be laid with as much evenness and regularity, and as little injury to the adjoining land as may be, and all the trees, logs, stumps, roots, bushes and rubbish shall be disposed of, with the like precaution; nor shall any unnecessary injury of any kind be done to the owners or occupants of the land through which the Canal passes. No Contractor shall place any logs, timber, earth or rubbish, in such a situation as to obstruct the works on any adjoining contract or part of the Canal. No highway or road which crosses the line of the Canal, shall be obstructed by excavation or otherwise, until the materials for a bridge have been collected, nor until the Contractor shall have received notice from the Superintendent or the Engineer, to complete the construction of the Canal across such highway or road.

APPENDIX B

Items, quantities and prices of the original estimates. The actual work, however, was changed somewhat.

Item	Unit	Farmington		Hampshire & Hampden	
		Quantity	Cost	Quantity	Cost
Earth excavation	Cu. yd. 4c			52,918	\$2,116.72
	" " 4½			9,247	416.11
	" " 5			280,030	14,001.50
	" " 6			148,623	8,917.38
	" " 6½			48,991	3,184.41
	" " 7	820,660	\$57,441.30	264,060	18,484.20
	" " 8	369,407	29,552.56	184,104	14,728.32
	" " 9	129,792	11,681.28	134,506	12,105.54
	" " 10	384,374	38,437.40	92,044	9,204.40
	" " 12	79,567	9,548.04		
	" " 15			186,750	28,012.50
Total, Farmington		Cu. (Av. 8.22)	1,783,800		
" Hampshire		" (" 7.93)		1,401,273	\$111,171.08
" Both		" (" 8.10)	3,185,073 cu. yds.		\$257,831.66
Embankment	Cu. yd. 5c			5,816	\$290.80
	" " 6			51,625	3,097.44
	" " 7			98,482	6,893.74
	" " 7½			20,315	1,523.62
	" " 8			195,756	15,660.48
	" " 9	8,800	\$791.17	131,190	11,807.10
	" " 10	159,019	18,621.80		
	" " 12	166,356	19,962.72		
	" " 13	39,361	5,116.93		
	" " 14	85,712	11,999.68		
	" " 16	32,349	5,175.84		
Total, Farmington		Cu. (Av. 12.54)	491,597		
" Hampshire		" (" 7.80)		503,183	\$39,273.18
" Both		" (" 10.15)	994,780 cu. yds.		\$100,941.32
Rock excavation	Cu. yd. 25c			1,403	\$350.75
	" " 30			8,539	2,561.70
	" " 40			888	355.20
	" " 50			1,812	906.00
	" " 60			721	432.60
Total, Farmington		" " 75	650		
			\$487.50		

<i>Item</i>	<i>Unit Price</i>	<i>Farmington Quantity</i>	<i>Cost</i>	<i>Hampshire & Hampden Quantity</i>	<i>Cost</i>
Total, Hampshire	(Av. yd. 34.47)			13,363	\$4,606.25
“ Both	(“ “ 36.35)	14,013 cu. yds.			\$5,093.75
Removing rock	Lump Sums				
Diking	Lump Sum				\$800.00
Towing Path	Lump Sum		40.00		
	Chain \$3.00	36	108.00		
floating (700 ft.)	Lump Sum				\$350.00
on aqueduct	“ “				175.00
Grubbing & Clearing	Lump Sums		\$4,965.00		\$4,180.00
Masonry	Perch \$2 00			6,446	\$12,892.00
Culverts	Lump Sums		\$18,350.00		
Dams, Munn Brook, feeder	“ “				100.00
Little River feeder	“ “				130.00
20' long x 8' high	“ “		150 00		
Unionville feeder	“ “		250.00		
Little River, pool	“ “				350.00
Westfield R. feeder	“ “				3,000.00
Waste weirs (H&H with fence)	“ “		5,000.00		
Slope walls	y. 30c	5,049	1,514.70		
	“ 50	396	198.00		
Drain, stone	Lump Sum				50.00
Aqueduct, Trunk only	lin. ft. 5.12½			654	\$3,351.75
8 Mile River (20 ft.)	Complete		\$1,000.00		
Mill “ (40 “)	“		1,600.00		
Farmington River (200 “)	“		10,000.00		
Bridges, Farm	Each \$60.00			20	\$1,200.00
	“ 80.00	3	\$240.00		
	“ 100.00	74	7,400.00		
Road	“ 85 00			35	2,975.00
	“ 100.00	3	300.00	1	100.00
	“ 150.00	63	9,450.00		
	“ 187.50			2	375.00
in New Haven	“ 500.00	9	4,500.00		
Feeder canal	Lump Sum				627.00
Lockage	ft. lift \$160.00			40	\$6,400 00
	“ “ 164.00			134	21,976.00
	“ “ 170.00			48	8,160.00
	“ “ 200.00	218	\$43,600.00		
Double	“ “ 324 00			76	24,624.00
Guard	Lump Sum		500.00		
	“ “		1,000.00		
	“ “			2	3,000.00
Keepers' Houses	Lump Sum		10,000.00		
Fences	Lump Sum		29,000.00		
and waste weirs	“ “				\$15,400.00
Puddling	Lump Sum		10,000.00		
Engineering & Superintendence			19,000.00		
Contingencies	Lump Sum		32,063.00		
Total			420,697.88*†		290,000.00

* The extensions of Wright's figures, in the only copy known are incorrect in several cases; they actually total \$420,014.22.

† “Damages to Land, Houses, etc., to be added.”

APPENDIX C
LIST OF STRUCTURES
LOCKS IN CONNECTICUT

Locks Nos.	Location	Rise or Fall	Remarks
1 to 6 inclusive 7 and 8 9	North of Granby Station Southington Milledale	37½' down 18' down 8' down	Traces of masonry left. Traces of masonry left. No traces found.
10 and 11 12	Cheshire Brooksville	15' down 9' down	A little masonry left. Masonry practically intact.
13	Cheshire-Hamden Line	8' down	Some little masonry left.
14	North of Mount Carmel	13' down	Considerable masonry left.
15	North of Mount Carmel	28' down	Some little masonry left.
16, 17 and 18 19	South of Mount Carmel South of Skiff Street, Hamden	24' down	No traces found. Very slight traces left.
20	North of Mather Street, Hamden		No traces found.
21	South of Putnam Avenue, Hamden		No traces found.
22	Hamden-New Haven Line		No traces found.
23, 24 and 25 26	Near Henry Street, New Haven	59½' down	No traces found.
27	Between Temple and Church North of Wall Street		Much of west wall remains.
28	Between Chapel and Wooster		No traces found.

The 28 Connecticut Locks had a continuous descent from Massachusetts to Long Island Sound, of 220 feet.

LOCKS IN MASSACHUSETTS

Locks Nos.	Location	Rise or Fall	Remarks
1 to 7 inclusive 8 and 9 10 to 18 inclusive 19, 20 and 21 22 23 and 24 25, 26 and 27 28 to 32 inclusive	Just North of Congamond Ponds One mile north of Congamond Ponds Just North of Westfield Just South of Southampton Just South of Southampton Just North of Southampton South of Easthampton At the Connecticut River	56' down 23' down 90' up 40' down 20' up 26' up 48' up	Traces of masonry only. A little masonry left. Traces of location only. Traces only. East wall practically intact. Traces only. Traces only. Some wrecked masonry left.

The 32 Massachusetts Locks had first 79 feet of descent, then 90 feet of rise, then 134 feet of descent. The entire Canal thus had 60 locks, with 292 feet of rise and 213 feet descent, going from the Sound to the Connecticut River.

AQUEDUCTS IN CONNECTICUT

CROSSING	LOCATION	SPAN		ESTIMATE	REMARKS
		TOTAL	No.		
Farmington River	North of Farmington	200	7	\$10,000.	Actually built 280 feet long. North abutment and 3 piers in fair condition; South abutment and 3 piers have been taken down to level of ground. No traces found. No traces found.
Eight Mile River Mill River	Southington Mount Carmel	40 20	1 1	1,600. 1,000.	

AQUEDUCTS IN MASSACHUSETTS

		?	?	?	Not listed	
Little River	Westfield				Trunk	Traces of masonry foundations.
Westfield River	Westfield	300	?		Masonry	Doubtful traces
Manhan River	Southampton	30	1		Trunk	Abutments in R. R. bridge
					Masonry	
North Manhan River	Easthampton	60	1		Trunk	Abutments in Highway bridge
					Masonry	
Lickingwater	Northampton	246	?		Trunk	Doubtful traces
					Masonry	

"Trunk" @ \$5.12½ per lin. ft.; Masonry @ \$2.00 per "perch" of 24¾ cu. ft.

CULVERTS IN CONNECTICUT

OVER	LOCATION	SPAN	ESTIMATE	CONDITION	CARRYING
Salmon Brook	Granby	40 (30)	\$4,000.	Excellent	Railroad
..... Brook	Hoskins	5	150.	Ends gone	Farm road
..... Brook	Simsbury	4	150.	Excellent	25' embankment
Hop Brook	Simsbury	16 (14)	1,500.	Middle gone	Private roads
..... Brook	Simsbury-Avon Line	4	150.	Ends gone	6' embankment
Nod Brook	Avon	12 (14)	1,500.	Excellent; (partly rebuilt?)	Highway No. 10
Woodruff Brook	South of Avon	6 (6)	500.	Excellent	Highway, no number
Mill Brook	North of Aqueduct	10 (14)	800.	Only west end left	Uncovered
Ice Pond	Farmington	.4	150.	Excellent	10' embankment
10 Mile River	Milldale	18	3,500.	Excellent	60' embankment
Roaring Brook	Brooksville	18	Excellent	Railroad
Eaton Brook	Mount Carmel	8	150.	Excellent	Railroad
Shepherd's Brook	Centerville	12 (14)	1,500.	Excellent; (partly rebuilt?)	Highway No. 10

All except Roaring Brook, which was built by the railroad in 1847, are semi-circular arches, springing either directly from the plank grillage, or from side walls, not over 2 feet high, on the grillage.

Roaring Brook is a 3 centred, 50° 30' skew arch, with radii of 6 feet, 12 feet, and 6 feet. Normal Span, 18 feet; face span, 28 feet.

CULVERTS IN MASSACHUSETTS

OVER	LOCATION	SPAN	ESTIMATE	CONDITION	CARRYING
..... Brook	Southampton	3' box	\$ 134.	Excellent	Railroad
..... Brook	Southampton	3' box	180.	Excellent	Railroad
Saw Mill Brook	Easthampton	10' Arch (10)	542.	Excellent	Highway
..... Brook	East-North. Line	(3)	130.	Traces only	In woods
Rocky Hill Brook	Northampton	3' box (3)	192.	Excellent	Railroad
..... Brook	Northampton	3' box (3)	200.	Excellent	Railroad

Hurd's report lists 15 culverts under the main canal, but the above are all that were located. It is a question whether or no the box culverts are canal culverts; they evidently are old, but Hurd refers to them as arches.

WESTFIELD RIVER FEEDER CULVERTS

Moose Meadow Brook	12'	\$ 380.	Only south end remains	Uncovered, in fields
Sacketts Brook	6' (6')	Only wrecked grillage remains	Uncovered, in fields

A total of \$376 is given for this and a 3' span culvert over "Powder Mill Brook."
Span figures in parentheses are those given in the estimate.

APPENDIX D

A partial bibliography of the Northampton Canal, with some notes as to the material.

An / Account of the / Farmington Canal Company / etc.

Twenty-four page official report issued by direction of the President of the New Haven and Northampton Company in 1850. Excellent account.

A Connected View / of / The Whole Internal Navigation / of / The United States / etc. George Armroyd.

Brief notes with some little data.

History / of / The City of New Haven / etc. Edward F. Atwater.

Excellent article by George D. Watrous.

History / of / Southington, Conn. / etc. Francis Atwater.

Good account.

Farmington Canal / To the / Citizens of New Haven.

Pamphlet opposing proposed location.

1786 Centenary of Hamden, Connecticut, 1886 / etc. Wm. P. Blake.

A brief account.

Farmington, Connecticut / The Village of Beautiful Homes / etc.

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Excellent local account by Julius Gay.

Calm Considerations Relative to the Canal.

Local propaganda—8 page pamphlet.

History / of / Plainville / Connecticut / etc. Henry A. Castle.

Excellent local account.

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Amendment / of the / Charter / of the / New Haven and Northampton Company / etc. (To permit construction of railroad.) Pamphlet.

The / Act of Incorporation / of the / Farmington Canal Company / with the / Reports / of the / Hon. Benjamin Wright / etc. 16 page pamphlet.

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A / Gazetteer / of / Massachusetts / etc. John Hayward.
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 the / Canal, from the termination / of the Farmington / Canal to
 Northampton.

Map / Exhibiting the / Farmington & Hampshire & Hampden / Canals / etc.
 N. & P. P. Jocelyn.

Western Massachusetts / A History / etc. J. H. Lockwood.
 Excellent account, chiefly of Massachusetts portion.

Westfield / and its Historic Influence. / J. H. Lockwood.
 Same account, practically, as in "Western Massachusetts."

Map / of the / Farmington / Canal.
 Original location plans.

Town Plans, Massachusetts (In office of the Secretary of the Commonwealth.)
 Easthampton. Atlas No. 14. Map 15.
 Northampton. Atlas No. 14. Map No. 22.
 Russell. Atlas No. 10. Map No. 19.
 Southampton. Atlas No. 7. Map No. 15.
 Southwick. Atlas No. 10. Map No. 20.
 Westfield. Atlas No. 13. Map No. 13.
 (Office of Secretary of the Commonwealth, Massachusetts.)

The/ Story of Connecticut / etc. Lewis Sprague Mills.
Good brief account.

History / of / New Haven County / etc. Mary H. Mitchell.
Good general account.

Compendium / of the / Internal Improvements / of the / United States, etc.
Samuel A. Mitchell.
Brief note, but with much data.

Charters / of / The New York, New Haven and Hartford / Railroad Company /
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"Who was Who on the Old Canal"

New Haven Chronicle about April 28, 1908.

No reference is here made to the extensive material regarding the extension of the canal system north of Northampton, and that which is very closely related to it, the projected improvements of the Connecticut River at that time, nor does the above list pretend to be at all complete; it does, however, include the more important material examined to date by the author.