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HISTORIC STRUCTURE REPORT
DRY DOCK I
CHARLESTOWN NAVY YARD
ARCHITECTURAL DATA
BOSTON NATIONAL HISTORICAL PARK
MASSACHUSETTS

by

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I. ADMINISTRATIVE DATA

A. Name and Number of Structure

Dry Dock #1, Charlestown Naval Shipyard, Charlestown, Mass., a 398 foot dry dock, originally built of Quincy granite in 1833, is the sole remaining operative dock at the Charlestown site.

B. Proposed Use of Structure

Dry Dock #1 will be preserved to continue its useful tradition of enabling rapid ship repair for any on-site vessels requiring extensive or prolonged maintenance.

C. Justification for Such Use

Like the Charlestown Navy Yard, Dry Dock #1 has been altered over the years reflecting the technical developments and achievements of the US Navy. It has been enlarged twice since 1833, with modifications made to the floor of the dock and at the head end.

As a former naval shipyard, with two on-site vessels--USS CONSTITUTION and USS CASSIN YOUNG--this dock exists as the one on-site repair facility. Use of a similar off-site repair facility would be costly, and, potentially, injurious to these cultural resources.

D. Provision for Operating Structure

Dry Dock #1 can be used as the Naval Yard's ship repair facility as well as an interpretive tool signifying past technological advances in the field of civil engineering.

E. Cooperative Agreement, if any, Executed or Proposed for Operating Structure

In consideration for the permanent loan of the USS CASSIN YOUNG, the Department of the Interior shall permit the Navy to use Dry Dock #1 at the Charlestown Navy Yard for docking the USS CONSTITUTION at the Navy's expense from time to time (estimated 10 year intervals) or on an emergency basis.

F. Brief Description of Proposed Construction Activity

This information will be provided by the architectural historian when he prepares the Architectural Data Section of the Historic Structure Report on Dry Dock #1.

G. Estimated Cost of Proposed Construction Activity

This information will be provided by the architectural historian in the Architectural Data Section.

II. ARCHITECTURAL DATA

A. Significance

Dry Dock 1 at the Charlestown Navy Yard, Boston National Historical Park was designed and built by Loammi Baldwin between 1827 and 1833. Baldwin built a twin dry dock in Norfolk, Virginia during this same period. Baldwin's dry docks were the first to be built in America. The engineer had traveled abroad and had examined docks in England, France, and Holland. He then set to work to adapt the technology used in Europe to the materials and needs of the American continent. The resulting pioneering structures remain great achievements in the field of civil engineering.

An Englishman David Stevenson visited America shortly after the dry docks were completed. He described them in his book A Sketch of Civil Engineering in North America published in London in 1838:

> The only graving docks existing in North America, at the time of my visit, were those which have been erected for the use of the Navy by the Government of the United States, in the navy-yards of Boston in Massachusetts, and Norfolk in Virginia. These docks have been formed of such a size, as to admit with ease, the largest class of government vessels belonging to the American Navy. . . . The stone used in their construction is a grey-coloured granite from Quincy in Massachusetts, and, as far as regards workmanship and general execution they are inferior to no marine works which I have ever seen. . . . They are the finest specimins of masonry which I met with in America, and are equally creditable to the government of the United States, and to Mr. Baldwin, the engineer under whose direction they were constructed.

The significance of the dry docks does not rest solely on the quality and ingenuity of their construction. They must also be viewed as one of the important public improvements undertaken during the administration of President John Adams. Baldwin advocated the development of national roads and canals. He argued that such improvements were essential to a nation of commerce. He argued that dry docks would contribute to the public welfare through their use in building and maintaining a strong navy. This navy would protect merchant shipping which would in turn benefit markets throughout the country.

Another reason that the Dry Dock is historically significant is because of its early application of the steam engine. This was the first steam engine to be used at the Navy Yard. Engine making in Boston began in the early 1820s and Ebenezer Lester, inventor of the Dry Dock steam engine, built a number of the earliest engines in Boston.

The significance of Loammi Baldwin's dry docks has been recognized both by the inclusion of Dry Dock 1 in the Charlestown Navy Yard, Boston National Historical Park and by the designation of both dry docks as National Historic Civil Engineering Landmarks. This designation was made by the American Society of Civil Engineers on April 10, 1978.

B. Historical Material

Chapter 1: Developmental History

As early as 1804 Loammi Baldwin, one of New England's foremost civil engineers, advocated the construction of dry docks in the United States. In a series of articles appearing in Boston's Columbia Centinel in that year, Baldwin presented an elaborate dry dock scheme that included factories and workshops as well as docks.[1] The proposed plans were extensive and was assessed by William Gray, merchant of Salem in the following statement: "I should rejoice to see the plan executed, but I think it is too vast for the fortunes of this country."[2]

Baldwin believed that the construction of dry docks would benefit the country as a whole through the benefits that they would afford the navy and private mercantile interests. The engineer looked to Europe saying,

> Many European nations have within a few years greatly improved in shipbuildings, both in the theory and manner of building them. This important improvement, especially in the mechanical part of the work has been chiefly owing to their wisely adopting the dry docks. In England the dry docks have but lately been adopted; but in France, at Toulon, Brest, and Rochefort dry docks or bassins de construction have been in use near a centruy.[3]

Loammi Baldwin traveled through England and France in 1823. He examined the port of London noting that "the docks are truly noble works. I have examined some of the dry docks along the river where the merchant ships are repaired. Their construction is very simple and might be built at Boston at little expense. I have no doubt they would be found useful."[4]

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1. Loammi Baldwin, "Dry Docks" in Thoughts on the Study of Political Economy (reprinted, New York: August M. Kelly, 1968). Hereafter cited as Baldwin, "Dry Docks."

2. Frederick K. Abbott, "The Role of the Civil Engineer in Internal Improvements: The Contributions of the Two Loammi Baldwins, Father and Son 1776-1838." Ph.D. dissertation, Columbia University, 1952, p. 66. Hereafter cited as Abbott, "Baldwin."

3. Baldwin, "Dry Docks."

4. Abbott, "Baldwin," p. 131.

Upon his return to the United States in 1824, twenty years after he first presented a dry dock proposal, Baldwin began to correspond with Secretary of the Navy Samuel Southard concerning the construction of naval dry docks. A study of possible sites for a dock was authorized by Congress on November 25, 1824.[5] Early design plans were general and were to be adapted to a specific site later, although the engineer did have Charlestown in mind. Dry docks were rare in North America and Baldwin's designs were the first stone graving docks to be constructed on this side of the Atlantic. As such Baldwin's dry docks were important pioneering efforts.

The earliest report that Loammi Baldwin made "relative to the Dry Dock in Charlestown" was sent to Secretary Southard in November, 1824. His letter accompanying the plans and report contained the following observation on the project at hand: "The subject is totally new in our country and perhaps there is not in the United States a single engineer who has ever been employed in constructing a Dry Dock." At this time Baldwin estimated the cost of a masonry dock at $280,000.[6] Baldwin corresponded with Secretary Southard and Commodore Charles Norris on the subject of docks for several years. In August 1826 the engineer began detailed surveys of the navy yards at Portsmouth, New Hampshire, Charlestown, Massachusetts, Brooklyn, New York, and Norfolk, Virginia. He submitted a report on each of the four possible dock sites to Congress in January 1827. In March of that same year Congress authorized the construction of two dry docks, one at Charlestown, the other at Norfolk.[7] Loammi Baldwin was appointed engineer to superintend the

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5. Ibid., p. 136.

6. Loammi Baldwin to Samuel Southard, November 6, 1824, Baldwin Collection, Wm. L. Clements Library, University of Michigan, Ann Arbor, Michigan.

7. Abbott, "Baldwin," p. 154.

construction of the docks on March 28, 1827 at the request of President John Quincy Adams. He was given full authority over the project and was directed to report to the Board of Navy Commissioners made up of Commodores Bainbridge, Morris, and Chauncy.[8]

On June 1, 1827, Baldwin began preparatory work for the construction of the Dry Dock at Charlestown. Intending to spend summers in Massachusetts and winters in Virginia, Baldwin appointed his brother James Fowle Baldwin to be his assistant. James left after several months to work on other engineering projects.[9] At that time Alexander Parris, noted Boston architect, was appointed to help Baldwin superintend construction.[10] He was paid $160 per month. Others hired to work on the Charlestown dock included William Andem, clerk, Edward Battles, "a principal overseer of the works or head carpenter," Benjamin Perham, surveyor, and three assistants. The assistants were young men taking advantage of the only way to learn the profession of civil engineering, by apprenticeship. They were paid $1 a day when they were employed.[11]

Preparatory work for the dock construction included advertising for materials. On June 12 advertisements requesting timber and stone for the piers, cofferdam, and quay walls adjacent to the dock site, appeared in Boston newspapers. Actual construction did not progress as quickly as anticipated and the tide was not excluded

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8. Loammi Baldwin to Board of Navy Commissioners, "Annual Report for the Year 1827," Baldwin Collection, vol. 70, Baker Library, Harvard University, Cambridge, Massachusetts. Hereafter cited as Baldwin, "Annual Report 1827."

9. Ibid.

10. Abbott, "Baldwin," p. 155.

11. "Payroll of workmen on the dry dock in Charlestown Navy Yard from June 16, 1827 to Sept. 30, 1833." Baldwin Collection, Institute Archives, M.I.T., Cambridge Massachusetts.

from the construction site until the spring of 1828.[12] While the site preparation was being done, Baldwin studied the tides in Boston Harbor and completed final plans for the docks. His studies during this period resulted in several changes to the dock design.

The first change that Baldwin made to his preliminary plans for the Dry Dock was to increase its depth so that it would withstand the highest tides that occurred in the harbor. The depth finally decided upon was thirty feet from the coping to the gate sill.[13] Water was to be excluded from the Dry Dock through the use of turning gates and a floating gate. When the gates were closed the dock could be pumped dry. The second change Baldwin made to his original dock design was explained to the Board of Navy Commissioners in the engineers annual report of November 10, 1827.

> The floating gate originally proposed, was intended to rest against a shoulder at the entrance, so that when brought to its place, it should be retained there, on pumping out the Dock, by the horizontal pressure of the water. In that case, neither the floating gate nor the turning gates, would serve to retain the water inside the Dock, at a level above the tide, so that the water in the Dock would necessarily fall with the falling of the tide. . . . To guard against evils of this kind I concluded it better to construct the floating gate & the masonry of the Dock in such a manner as to let the gate drop into grooves in the side, walls & bottom, so as to resist pressure in either direction.[14]

Structures built to prepare the site for the Dry Dock construction included dry masonry quay walls on either side of the site as well as a cofferdam. The main part of the cofferdam was fifty feet below the entrance of the Dry Dock at right angles to the dock's axis. It extended 100 feet across the space between the two wharves flanking the dock site. As described by Baldwin,

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12. Baldwin, "Annual Report 1827."

13. Ibid.

14. Ibid.

> . . . instead of being on a straight line, it has an angle of 150 degrees in the middle, extending outwards, so as to give additional strength against the tides. This part will be chiefly composed of two rows of timber sheet piling from 12 to 14 inches thick, grooved & tongued, with an interior space between them of 13 feet, to be filled with good earth; with girders, tie bolts & timber caps. From each end of this part of the Dam, where it meets the wharf, the Coffer dam runs in a diagonal line through the wharf, till it meets and is carried through the Dry quay walls before described, the lines of sheet piling to be continued through the wall about 10 feet so as to be surrounded with the earth filling, and then prevent the passage of water round the ends of the dam. This part of the coffer dam will have the oak piles of the pier wharf to support it, & has a space only 8 feet wide between the sheet piling, which is composed of timber piles from 7 to 10 inches thick grooved & tongued. The girders or ribons, against which the sheet piles are driven, and which serve to guide them in driving, are secured to two of the diagonal rows of wharf piles previously driven, leaving an intermediate row within the dam.[15]

The ground into which the cofferdam piles were driven was a firm compact bed of clay.[16]

Wharf construction adjacent to the site of the Dry Dock included a new wharf east of the dock site and an extension to the Old Wharf which had been constructed in 1813 just west of the site. (See Illustration No. 3.) To build the wharves oak piles were driven 8 feet on center except for the end piles which were placed only 5 feet 5 inches from the next pile. A cap timber with tenon and shoulder joint was laid on the piles and a course of "small timber" was placed over this line of caps. Two feet of earth covering was laid on this deck and was retained in place by "a course of side capping" rising 3 feet to the level of the top of the wharf. Fender piles were driven around the side of the wharf against each row of bearing piles and were firmly bolted to the side capping. Oak girders were bolted to the bearing piles just above the low water mark providing additional strength. Five belay posts were driven on each side of the new wharf rising 5 to 6 feet above the level of the wharf's surface. Of similar construction, the extension of the 1813 wharf had two belay posts.

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15. Ibid.

16. Ibid.

Baldwin advertised for materials for the Dry Dock in September 1828 (see Appendix A). As a result a contract was made with William P. Riddle for the timber and plank for the flooring of the Dock. Several contracts were made with Ebenezer Lester for steam engines and pumps. Of primary importance was the granite to be used in the dock construction. The engineer reported to the Board of Navy Commissioner in November that

> Having on the 28th September advertised for proposals for deliverying the stone for building the Dock, to be received until the 1st of this month, I am now engaged in arranging a contract with Gridley Bryant upon his proposals, upon which he offers to furnish all the stone both for the hammered & Ruble work at $3 pr cubic yard, & it is estimated that about $20,000 yards will be required.

Gridley Bryant operated as agent for the Granite Railway Company in Quincy, Massachusetts. Baldwin included the following list of contracts that had been made by the U.S. Government in his annual report in 1827:

First	Richard H. Ayre, for cofferdam timber dated July 19, 1827
Second	Gridley Bryant's contract for dry quay wall, dated July 24, 1827.
Third	Ebenezer A. Lester's contract for great steam engine dated July 24, 1827
Fourth	William P. Riddle's contract for Wharf piles, etc. dated July 28, 1827
Fifth	Shubart Bills' contract for ballast for backing dry quay wall, dated July 30, 1827
Sixth	Hugh Cummisky's contract for covering wharf with earth, filling cofferdam, & backing up quay wall, dated Oct. 10, 1827
Seventh	William P. Riddle's contract for timber & plank for foundation floor of Dock, dated Oct. 27, 1827

Eighth Ebenezer A. Lester's contract for small temporary engine for draining with pumps etc. dated Nov. 10, 1827

Ninth Gridley Bryant's contract for stone, for hammered, ashler, & ruble work, supposed about 20,000 cubic yards at $3 per yard delivered rough.[17]

On November 1, 1827, Mr. Stuart J. Park was hired to superintend the stone cutting. The first shipment of stone was delivered by the Granite Railway Co. on April 26, 1828. As the stone was delivered rough, much of the hammering or finishing of the stone was done by workers from the State Prison.[18]

Favorable weather conditions during the spring and summer of 1828 permitted excellent progress on the cofferdam, quay walls, and wharves. Lester's small engine, for pumping out the dock foundation during construction, was erected but not yet in use in November, 1828. Baldwin noted that on May 21 "the enclosure of the Dock basin was so far completed by filling the Coffer dam, & by the embankment behind the quay wall, as to justify excluding the tide by closing the valve on the Culvert through the Coffer dam. . . ." Excavation for the foundation of the Dock was begun on May 26.[19]

Several temporary buildings were erected at the Dry Dock site. The location of some of these structures is noted on Baldwin's plan of the construction site dated November 4, 1828. This plan was included in his annual report to the Board of Navy Commissioners (see Photograph 3). In this annual report the engineer describes the temporary buildings as follows:

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17. Ibid.

18. "A Diary Kept at the Dry Dock Office, Navy Yard Charlestown, Nov. 1, 1827-May 16, 1828," Baldwin Collection, Institute Archives, M.I.T., Cambridge, Massachusetts.

19. Loammi Baldwin to Board of Navy Commissioners, "Annual Report for the Year 1828," Baldwin Collection, vol. 70, Baker Library, Harvard University, Cambridge, Massachusetts. Hereafter cited as "Annual Report 1828."

> An office with two rooms, 45 by 20 feet. An old carpenters shop removed and fitted up 56 by 30 feet. A Blacksmith Shop 50 by 20 feet with 5 forges, & a coal shed 24 feet square. A shed for cement etc. 71 by 30, a carpenters shed 61 by 30 & one 63 by 29 feet. A steam engine house 33 by 32 feet.[20]

Baldwin had initially made a contract with Ebenezer Lester for the "Great steam engine for draining the Dock when completed." Upon realizing that the siting of this engine would depend upon the overall plans for the development of the navy yard, Baldwin chose to make a second contract for a smaller steam engine to pump out the dock foundation (see Appendix B). In November 1828 Baldwin wrote:

> The temporary engine of about 15 horse power was erected last winter . . . & 2 cast iron pumps of 12 inches diameter each, have been put up, & the machinery is constructed to carry two more, should they be found necessary. The pumps are in a well . . . . Into this well it was intended to conduct the water as the excavation deepened. But as very little water comes into the part already excavated, & that fresh water, it is lifted by two small wooden pumps about 12 feet high, & then runs into the great wells where it is raised by the great pumps . . . .[21]

Excavation for the Dry Dock foundation continued in the spring of 1829 and was completed that September. There were several problems with the coffer dam during this time because of the soft nature of the soil. Additional piles were driven as bracing. On November 5, 1829, Baldwin reported that the foundation floor of the dock required but several days work before being completed. The last foundation pile was driven on October 27, 1829.[22]

Loammi Baldwin spent much time studying and experimenting in order to choose the best cement for the masonry work. The product used was provided by Peter Remsen & Company of New York. The mix used was stated in Baldwin's report for the year 1829.

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20. Ibid.

21. Ibid.

22. Loammi Baldwin to Board of Navy Commissioners, "Annual Report for the Year 1829," Baldwin Collection, vol. 73, Baker Library. Hereafter cited as "Annual Report 1829."

> We have found that an excellent composition for the mass of masonry is obtained, by mixing common lime after being slacked, with the cement. A cask of lime with a cask of cement, & a due proportion of sand, makes a mortar which soon hardens, & in such works, it may be found highly serviceable & much cheaper than cement alone. When very hard & firm water cement is required, for face work & c. we use cement & sand altogether the mixture being half sand, & half cement.[23]

The foundation of the Dry Dock as constructed by Baldwin was 341 feet long and 100 feet wide resting on 4,037 piles. The piles were driven approximately three feet on centers into a heterogeneous mass of clay, sand, mud, and gravel. At the head of the Dock piles were driven closer together to support the additional weight of the masonry. The first layer of floor timbers which was placed on the piles which were sawed off and planed, was made up of cap sills or mud sills one foot square. These timbers were secured in the following manner.

> At every third or fourth pile, the mud sill has a dovetailed mortice 2 inches thick, to correspond to a tenon made on the top of the pile as wide as the diameter of the pile will admit. These tenons run through the timber, & by wedges, the timber is held firmly down on the piles. Treenails or bolts are also driven through the sills into the tops of the piles on which they rest where the sill & piles are not connected by mortices & tenons.[24]

A course of pine planks three inches thick was laid on top of the sills and fastened with spikes so as to be watertight. Rows of four-inch plank tongue and groove sheetpiling was driven underneath the heaviest masonry to provide additional support. Such walls were driven under the head of the Dock, under the turning gates, under the floating gate, and under the wing walls of the Dry Dock.

A second layer of square floor timbers was laid on the plank floor. A second plank floor was then placed above to hold the stonework of the Dock's floor and walls. On March 18, 1829 Baldwin wrote an enlightening letter concerning the excavation and foundation of Dry Dock 1. It is worthy of note.

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23. Ibid.

24. Loammi Baldwin papers in John R. Freeman Collection, Institute Archives, M.I.T., Cambridge, Massachusetts.

> The excavation was made to an average depth of 4 inches below the tops of the foundation piles, so as to leave room for the workmen to saw off, & level the tops of the piles. All the spaces under the mud sills were carefully filled up with stone as an underpinning, and between them the spaces were also filled up by large stones as compactly as possible, & even with the tops of the timbers, but without mortar or cement. Sand was next placed on the whole & washed in with water, to fill all the interstices among the stones, thus making a compact mass of stone & sand under & between the timbers level with their tops . . . . As the floor timbers were laid perpendicularly over the mud sills & piles, their centers were generally about 3 feet apart, and they were generally a little more than 1 foot thick, the space between them was about 2 feet wide 100 feet long & under the Dock chamber 1.33 feet deep; but under the turning gates they were only 1 foot deep. All these spaces were closely filled with hard burned bricks, laid in hydraulic lime mixed with sand, even or nearly even with the upper surface of the timber, so as to allow of this layer of mortar . . . on the bricks, to make a uniform surface with the timber . . . . Upon this course of floor timber the last floor of 3 inch plank was closely laid & spiked.[25]

On November 5, 1829, Baldwin reported to the Board of Navy Commissioners that the docks would most probably be completed in the spring of 1832.[26] By November 1830 three quarters of the masonry of the Dock had been laid; the height from the upper surface of the plank floor to the top of the coping measuring 36 feet. Work progressed without delays except for an occasional lack of granite which was not supplied as regularly or as quickly as it could have been laid. Construction of the Engine House had not yet begun due to the fact that its site was occupied by the stone and stone hammers.

One problem that was encountered during this period concerned a source for the supply of timber to be used for the turning gates. On November 6, 1830, Baldwin wrote that the contractor had complained of the difficulty in procuring timber of the required form & size. "Should we fail in getting the surved pieces," wrote the engineer, "the ribs must be formed or composed of planks bent & bolted together, to the required curvature."[27] The contractor failed to provide the

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25. Ibid.

26. "Annual Report 1928."

27. Loammi Baldwin to Board of Navy Commissioners, "Annual Report for the Year 1830," Baldwin Collection, vol. 73, Baker Library, Harvard University, Cambridge, Massachusetts.

required timber and the engineer was forced to form the curved elements of the gates by steaming planks, 7 inches thick and 18 inches wide, and fastening them together with copper bolts to form the curved ribs 21 inches thick and 18 inches wide.[28]

In November 1831 the masonry of the Dock and the great wells were completed and the engine house was nearing completion. Jetty walls had been constructed on either side of the Dock reaching as far as the coffer dam. The turning gates and drainage systems were under construction and the gravel paving which was to extend thirty feet wide around the Dock was to be started with the completion of the drainage systems. Baldwin had not yet started work on the floating gate as he felt that it should be built in the Dock to assure a proper fit.[29]

When Loammi Baldwin wrote his annual report to the Board of Navy Commissioners on November 6, 1832, the Dry Dock was nearing completion. All contracts had been fulfilled. On June 13, 1832, the great engine and pumps had been tested for the first time. Consisting of eight chain pumps with a working chamber 13½ inches in diameter and eight lift pumps, 2 feet 6 inches in diameter, they operated without problems. The jetty walls and turning gates had been completed and 7,000 square yards of paving had been laid around the Dock, leaving but 50 feet to be completed. The floating gate was under construction and the blocks were ready for placement in the Dry Dock. Work yet to be done included the removal of the cofferdam, dredging of the channel and completion of the wharves. All of this was completed before June 24, 1833. On that morning the Frigate Constitution became the first vessel to enter Baldwin's Dry Dock at the Navy Yard in Charlestown. The Norfolk dock had accepted its first ship earlier that same month.[30]

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28. Baldwin to Navy Commissioners, "Annual Report 1831," Baldwin Collection, vol. 69, Baker Library. Hereafter cited as "Annual Report 1831."

29. IBid.

30. Baldwin to Navy Commissioners, "Annual Report 1832," Baldwin Collection, Vol. 69, Baker Library.

On September 9, 1833, Loammi Baldwin turned the Charlestown Dry Dock over to the Navy with the following statement:

> In surrendering my old friend the Dry Dock into your hands I give up a subject which for five or six years has filled me with excitement and has produced alternately hopes, fears, and expectations of various characters, but never a doubt of its ultimate success. The dock is now completed. It satisfied my intentions and I believe fully meets the expectations of the public. May its faults never be discovered, and were I to build another, I think I could make one perfect.[31]

As originally constructed, Dry Dock 1 at the Charlestown Navy Yard, Boston National Historical Park, had exterior dimensions of 341 feet by 100 feet. The masonry, as has been noted, was granite provided by the Granite Railway Company of Quincy, Massachusetts. The stonework began at 32 feet below the high water mark and had the following dimensions:

From the outside of the wing-walls to the beginning of water-walls of entrance	5 ft. 9 in.
Thence to beginning of recesses for turning gates,	21 ft. 3 in.
To point of mitre sill,	21 ft. 8 in.
To line of heel posts of turning gates,	14 ft. 0 in.
To gutter,	18 ft. 0 in.
To face of return walls at foot of chamber of dock,	206 ft. 0 in.
To head of dock within the coping, being the radius of the head,	43 ft. 0 in.
To extreme end of backing at head,	7 ft. 3 in.[32]

The masonry was laid in cement with some iron fastenings such as cast iron dowels that were used to secure the coping stones.

The floor of the Dry Dock was 30 feet wide and 228 feet long between the first altars. At the coping the interior of the chamber was 86 feet by 253 feet to the face of the arch above the mitre sill. This was the area enclosed by the turning gates. If additional length was needed for the docking of a vessel the area

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31. Abbott, "Baldwin," p. 184.

32. "Dry Dock at Charlestown" in American Magazine of Useful and Entertaining Knowledge, vol. 1 (Boston: Bewick Co., 1835), p. 298. Hereafter cited as "Dry Dock at Charlestown."

between the turning and floating gates, 53 feet in length, could be utilized giving a total length of 306 feet.[33] The jetty walls on each side of the dock entrance extended 35 feet into the river.

The stone floor of the Dry Dock was 5½ feet thick at the head and reduced to 4 feet at the foot of the chamber. Under the turning gates the masonry was 4½ feet thick, while under the mitre sill and arches it measured 6 feet.[34] From the lower end of the Dock to its semi-circular head there was a rise of 1 foot 3 inches in a distance of 206 feet. A gutter one foot in width ran underneath the keel blocks at the center of the Dock carrying water to the discharging gutter at the lower end of the Dock.[35] The breadth of the side walls of the dock chamber was 35 feet at the base reduced to 7 feet at the coping by a series of altars from 1 to 4 feet high and 4 to 6 feet wide.[36]

There were six stairways into the chamber of the Dry Dock. Two were located at the head, one near the middle of each of the side walls, and one on either side of the lower end adjacent to the turning gates. There were slides called timber slips at the head of the dock chamber to facilitate the transport of materials into the dock. The slip at the center of the head of the dock was 5 feet wide from top to bottom with periodic landings.[37]

The operation of Baldwin's Dry Dock was described in 1835 as follows:

> When a ship is to be docked, the filling culverts are closed, as well as the passage from the dock to the discharging culverts and reservoir, and the water is pumped from the latter. The ship is then admitted, and the ponderous gates closed. In this situation, the discharging gates are drawn, and the water allowed to flow into the discharging culverts and reservoir, and thus, in a few minutes, the water is lowered several inches in the dock to hasten the shoring, and produce an immediate pressure on the gates, so as effectually to

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33. Charles B. Stuart, The Naval Dry Docks of the United States (New York: Chas. B. Norton, 1855), p. 61. Hereafter cited as Stuart, Naval Dry Docks.

34. Ibid., p. 61.

35. "Dry Dock at Charlestown," p. 298.

36. Ibid., p. 299.

37. Ibid., p. 299.

> prevent the admission of water, and fix them steadily. The reservoir and culverts contain above seventeen thousand cubic feet of water; the water in the dock, &c. supposed level with the top of the upper altar, or four feet below the coping, at one foot in depth, is a little more than twenty-one thousand feet; and of this quantity, a ship of the line admitted at full draught, would displace above nine thousand cubic feet; consequently, to reduce the water one foot when the ship is in dock, only twelve thousand feet need to be admitted to the reservoir and culverts; and the dock water may be lowered about one foot five inches to fill them. A complete command of the level, at the moment when a ship, especially a large one, is about to touch the blocks and to require the placing of shores, seems very important; and this mode will give a more perfect control of the operation, for the first foot, then could be obtained by the best regulated pumps or machinery.
>
> The water is afterwards to be pumped out by the steam engine near the head of the dock. As the water is lowered the ship is propped up by shores, and is then ready to undergo repairs, which can be conducted with great facility and security.[38]

The filling gates were located on the exterior face of the wing walls. They opened into the filling culverts, 2 feet 6 inches square, which ran 84 feet along the backing masonry of the side walls to connect with the square wells leading to arched culverts. These culverts were a continuation of the discharge gutter running the length of the chamber floor. The culverts measured 2 feet in width and 5 feet in height. Located in the masonry wing walls, they carried water to a point 40 feet from the dock's axis into side culverts 2 feet 6 inches by 4 feet, built of hard brick with semi-circular top and bottoms. The side culverts ran 250 feet to a reservoir from which the water was conducted through a brick tunnel, 4 feet by 2 feet 9 inches and 80 feet in length, and into the pumpwells. The water was then pumped up to a level from which it would drain through the discharge culverts, running the length of the dock, into the river. The discharge culvert was also brick and measured 3 feet square. The various culverts were regulated through the use of gates, made of composition metal, which could be opened and closed.[39]

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38. Ibid., p. 300.

39. Ibid., p. 299.

The pumpwells were 15 feet 9 inches in diameter, built of brick. The bottoms were inverted arches 2 feet thick. The side walls were 2 feet 6 inches thick with projecting courses of cut stone that supported the pump frames. The tops of the walls had a stone coping 1 foot deep and 18 inches wide.[40]

The turning gates, similar to ones Baldwin had observed at St. Katherine Docks in London, were described in 1835.[41]

> The turning gates, which are thirty feet ten inches high and about thirty-six feet wide each, are composed of twelve white oak ribs, two feet square, and carved into a radius of about seventy feet, tenanted into heel and mitre posts, planked and coppered. The heel post turns on a composition metal pivot, and two rollers are attached to the lower rib, one near the mitre post and one near the middle, and are made to traverse ton cast iron tram plates let into the floor of the dock. The gates are opened and shut by means of chains attached to the mitre posts and connecting with capstans placed on the coping. From the heel posts to the end of the gate recesses, the walls have a horizontal curvature, conformable to that of the gates. The mitre sill, against which the gates shut, and the floor over which they swing, are horizontal; the former being one foot six inches higher than the latter, and thirty feet below the top of the dock. The side walls of that part of the entrance, beginning at five feet nine inches from the sea, and extending to the recesses of the gates, are partly curved. The floor between the feet of the interior faces of these side walls is horizontal, and is thirty feet below the top of the dock. In these side walls and bottom is cut a groove of two feet wide and fifteen inches deep, to receive the floating gate, to be used in case the turning gates should require repairs, or to relieve the strain on them by dividing the pressure.[42]

The floating gate was built of white oak and yellow pine fastened with composition and copper bolts. It measured 60 feet in length, 30 feet in height, and 16 feet in breadth at the mid-point. The keel and stems projected 14 feet into the stone work of the Dock. Three feet from the top of the gate was the deck, eight

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40. Stuart, Naval Dry Docks, p. 62.

41. Sketch of turning gates, St. Katherine's Docks. Baldwin Collection, Wm. Clements Library.

42. "Dry Dock at Charlestown," p. 299.

cooper ship pumps each 8 inches in diameter used to empty the water from the caisson when it was to be floated out of its grooves to allow the docking of a vessel.[43]

Baldwin wrote of the floating gate with enthusiasm after the completion of the Dry Dock.

> The great and satisfactory result of this application of the floating gate has puzzled a good many people and I have no doubt has provoked some. It has afforded me a great gratification because the workmen were laughed at for working on such a damned, ugly, foolish thing. But they now say a tailor never made a pair of breeches to fit better.[44]

The great steam engine, used to power the pumps, was built by Lazell & Perkins & Company of Bridgewater, Massachusetts according to a design by Ebenezer Lester. It was a pendulum steam engine of 50 horsepower with a 16-inch cylinder and 5 wrought iron boilers burning anthracite coal to generate steam.[45] The operation of the great steam engine was described in The American Magazine of Useful and Entertaining Knowledge in 1835. (See Appendix D.)

Lester's engine powered the operation of eight lift pumps and eight chain pumps. The cast iron chain pumps consisted of a series of flat cast iron blades strung at regular intervals upon two parallel endless wrought iron chains which hung vertically from a sprocket wheel 34 inches in diameter. The blades were drawn through chamber 13 inches in diameter. Fiting tightly into the cylinder, the blades carried water up with them. The eight lift pumps forced water up through chambers 30 inches in diameter. Valves alternately opened and closed allowing water to be forced up through the chambers while preventing travel in the opposite direction.[46]

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43. Stuart, Naval Dry Docks, p. 64.

44. Abbott, "Baldwin," p. 182.

45. Stuart, Naval Dry Docks, p. 62.

46. "Dry Dock at Charlestown," p. 300.

Apparently the chain pumps, difficult to operate and maintain, were used for a relatively short period of time. In a letter to John Wade, dock master, dated March 11, 1834, Noah Butts, engineer, described the chain pumps as complex, susceptible to injury by wear and corrosion, requiring more power and room to operate than the lift pumps, and more difficult to repair.[47] When Charles B. Stuart described the operation of the Dock only the eight lift pumps were in use.[48]

The Dry Dock engine and pump wells were housed in the Engine House. (See Illustration No. 9.) Designed by Alexander Parris, this building also housed a sawmill that made use of the steam engine when it was not being used to pump out the Dock.[49] When $30,000 was requested for the construction of the Engine House on site 55 at the Navy Yard it was described in the following words: "The building of site 55 to be of granite completely fire-proof and to be used in part for the engine and pump connected with the dry dock, the remainder to be had for workshops, whose machinery will admit the most advantageous use of the engine when not required for the dock."[50]

In the construction of the Engine House, Parris employed a system of brick vaults resting on cast iron beams in sections of the building. The framing throughout is innovative for the period. The spanning members are a composite timber beam, split vertically with an iron element between. This is one of the earliest examples of prestressed beams.[51]

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47. Noah Butts to John Wade, March 11, 1834, v. 1/43, Constitution Museum, Charlestown Navy Yard, BNHP, Boston.

48. Stuart, Naval Dry Docks, p. 62.

49. David Wright, Helen Davis, and Edward Hatch, "Alexander Parris, Innovator in Naval Facility Architecture," The Journal for the Society for Industrial Archeology, Vol. 2, No. 1, 1978, p. 7. Hereafter cited as Wright et. al., "Parris."

50. George Henry Preble, "History of the Boston Navy Yard in Charlestown, Massachusetts from 1797 to 1875," MS, New England Historical and Geneological Society, Boston. Hereafter cited as Preble, "Boston Navy Yard."

51. Wright, "Parris," p. 7.

Today the Engine House, Building 22 at the Charlestown Navy Yard, Boston National Historical Park, houses the Constitution Museum. The innovative features of this structure may be viewed by the visitor.

EARLY MAINTENANCE OF DRY DOCK 1

Within ten years after completion, Dry Dock 1 required repairs. In the annual report to the Navy in 1842 funds were requested for repointing some of the masonry and repairing the paving around the Dock.[52] In that same year the entrance to the Dock was dredged and one year later a new set of blocks for the Dock and funds to repair the gates were requested.[53] In 1843 several repairs to the Dock were authorized including the repair of rainwater pipes. These repairs were completed prior to October 1, 1845.[54]

In 1845 it was requested that the drainage culvert from the pumpwells be extended to deep water to prevent mud from working into the mouth of the Dock. The estimated cost was $1,000.00.[55] The request for a new set of keel blocks was repeated in 1845 with a cost estimate of $500.00. Also requested were repairs to the turning gates at a cost of $2,500.00 and $200.00 in repair to the seawall at the northeast corner of the Dock.[56] The next year an urgent

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52. Boston Navy Yard, Annual Report 1842. Record Group 71, Entry 56, Records of Bureau of Yards & Docks, National Archives, Washington.

53. Boston Navy Yard, Annual Report 1843. Record Group 71, Entry 56, Records of Bureau of Yards & Docks, National Archives, Washington.

54. Boston Navy Yard, Annual Report 1846. Record Group 71, Entry 56, Records of Bureau of Yards & Docks, National Archives, Washington.

55. Boston Navy Yard, Annual Report 1844. Record Group 71, Entry 56, Records of Bureau of Yards & Docks, National Archives, Washington.

56. Boston Navy Yard, Annual Report 1845. Record Group 71, Entry 56, Records of Bureau of Yards & Docks, National Archives, Washington.

request was made for the replacement of the wooden foundation for the pumps with one of cast iron. The keel blocks and frame for the pumps were completed in 1849 and in that year it was proposed to pave the area around the Dock with granite blocks.[57]

In 1852 a major request for $3,500.00 was made for repairs to the Dry Dock gates. The annual report for the fiscal year 1853 contained the following description of repairs needed at the Dry Dock site.

> The gates to the Dry Dock are out of repair and must soon be put in order. The floating gate is in a very bad state, and as it will require extensive repairs--I would recommend an alteration in its construction, in conformity with the plan now submitted in order to reduce the draught which is now over twenty feet--and interferes with its convenient management--as it can now be moved only at the top of the tides. The turning gate is not so much out of repair but requires a new post and several rib timbers--the materials for which are on hand. . . . The Engine at the Dry Dock, having been in conststant use for many years--will by the next fiscal year, be required to be replaced with a new one or extensive repairs to the old one. . . .

The estimate for repairs to the floating gate was $9,417.00 and for those to the turning gate $3,092.00.[58] As a result of this evaluation an appropriation of $8,000 was made in 1854 for a new Dry Dock engine.[59]

The first major alterations to Baldwin's Dry Dock were proposed in 1855. The engine and pumps were being rebuilt, an additional $7,000 having been requested for that project. A request was also made for $10,000 to rebuild the Dry Dock engine boiler house. Most important, however, was a proposal to extend the Dry Dock 50 feet. The cost of this extension was estimated at $249,825.00. The additional 50 feet was considered necessary because the Dock was not large enough to accommodate the newer naval vessels.[60]

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57. Boston Navy Yard, Annual Report 1849, Record Group 71, Entry 56, Records of Bureau of Yards and Docks, National Archives, Washington.

58. Boston Navy Yard, Annual Report 1853, Record Group 71, Entry 56, Records of Bureau of Yards & Docks, National Archives, Washington.

59. Boston Navy Yard, Annual Report 1854, Record Group 71, Entry 56, Records of Bureau of Yards & Docks, National Archives, Washington.

60. Boston Navy Yard, Annual Report 1855, Record Group 71, Entry 56, Records of Bureau of Yards & Docks, National Archives, Washington.

EXTENSION OF DRY DOCK 1, 1856-1860

Although the extension of the Dry Dock was first proposed in 1855, it was more than a year later before the decision was made to extend the Dock and by how much.[61] The extension of the Dry Dock was authorized by Naval appropriation for the fiscal year beginning July 1, 1857. The initial amount allotted was $170,000 "for the addition of 65 feet in length to the Dry Dock." In 1858 an additional $80,000 was appropriated for the project.[62]

The ground underneath the addition to the Dock was very hard clay and it was decided that little additional stability would result from driving piles as had been done in the original construction. The stonework for the Dock extension was, therefore, laid directly on a clay foundation.[63] The work began on July 8, 1858. George Preble, in his history of the Naval Yard at Charlestown, notes that the original masonry had become so hard "that it was decided to use small charges of powder to shake it." Few of the original stones were injured while the head of the Dock was disassembled and most were replaced in their proper positions 65 feet inland. Most of the new stones set into the side walls were fastened by lewising and the courses were twice the width of the original work.[64]

The annual report for the year 1858 noted several changes to the Dry Dock necessitated by the extension, and the status of that work.

> The Paving and Drainage of the Portion of the Yard adjacent to the Dry Dock is very much in need of repairs throughout, and some considerable changes are required by the Extension of the Dock: it is therefore proposed to procure new stone for the Coping of the Circular Head of the Dock of larger dimensions of the old Work, reconstruct the surface Water Culverts and pave the surface with block

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61. Preble, "Boston Navy Yard," pp. 572-73.

62. Ibid., p. 574.

63. Ibid.,

64. Drawing "Isometric Projection of Half of the Head of Dry Dock, United States Navy Yard, Boston," Archives, Boston National Historical Park, Charlestown Navy Yard.

paving. The head of the Dock has been partially removed, the excavation entirely completed, a large portion of the rough stone laid and all the new Stone cut and delivered for the extension of the Dry dock. The culverts will be connected and completed, and a portion of the hammered stone set during the present season and it is confidently expected that this work will be completed during the next season.[65]

During the next year work progressed as expected, and in 1860 the extension of the Dock was completed. At this time granite block paving was laid around the Dock replacing earlier cobble stones.[66]

DRY DOCK MAINTENANCE
1860-1945

Following the extension of 1858-1860 no major work was done on the Dry Dock until 1872 when new wooden turning gates were installed.[67] In 1874 extensive repairs were required in the Dock. The Navy Yard's commandant reported that,

> The masonry of the Dry Dock is in a very bad way, from the lower or abutment end of the Dock, up to the extension or new work (284 feet). On the Southwest side the stone is either started or out from nearly every joint, and in both stairways there is more or less displacement of the stonework. On the Northeast side of the Dock, the pointing is not so bad, as on the Southwest side, but shows more leakage. Around the steps some of which are broken, and on both sides along the Altars of the old work, there is more or less displacement of the Stonework. The extension or new part (65 feet) requires some pointing, but otherwise, as far as can be seen, is in good condition. Around and between the Floating and Turning Gates, the leakage through the stonework is very bad. It is proposed to take up and relay all of the stonework around the stairways on both sides as far as practicable, and to thoroughly point all the work through the entire length of the Dock. It will require the construction of a Coffer Dam and will be a long and expensive job not less than $100,000 to commence with.[68]

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65. See Chapter 3.

66. Boston Navy Yard, Annual Report 1858, Record Group 71, Entry 56, Records of Bureau of Yards and Docks, National Archives, Washington.

67. Wright, "Parris," p. 80.

68. Preble, "Boston Navy Yard," p. 473-74.

Work was begun on the east wall of the Dock in June but proved to be so expensive that in July the Navy directed that no more stonework be displaced. The stones that had been taken up were relaid in Portland cement and joints adjacent to the entrance of the Dock were raked out and caulked with the same material. A total of $40,000 in repairs were completed by November 1874.[69]

The minor repairs that had been made to the Dry Dock masonry proved to be only a temporary remedy. By 1885 the Navy Yard in Charlestown was in a state of deterioration. Frost had destroyed the bond in the facing stones of the Dry Dock, "moving the stones from their places, and in the vicinity of the caisson, and at the head of the dock" causing serious leakage. A sum of $15,000 was requested to replace the stones and repoint other areas of the Dock.[70] In 1889 it was reported that the Dock was much in need of repairs. The wells and chain pipes under the capstans that operated the turning gates were always filled with water causing severe movement of the adjacent masonry. As the gates could easily be operated with a block and tackle the wells were filled with concrete.

By this time the joints in the Dock masonry had crumbled and water leaked into the joints freely. The ensuing freeze-thaw cycles opened these joints so much that it caused displacement of the altars. Repairs were made by cutting back the joints between 6 and 24 inches and grouting with mortar of one part "sharp grit sand" and three parts Portland cement slightly moistened. In the most severe cases strips of "monumental" lead were driven far into the seam which was then filled with the cement. Drains were cut into some of the altars and some broken stones were replaced. At the same time grating was installed in the openings to the culverts to prevent the entrance of foreign objects.[71]

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69. Ibid., pp. 474-75.

70. Boston Navy Yard, Annual Report 1886, Record Group 171. Records of Bureau of Yards and Docks. National Archives, Washington, D.C.

71. Boston Navy Yard, Annual Report 1889, Record Group 171, Records of Bureau of Yards and Docks, National Archives, Washington.

On December 4, 1890, a contract was made with the Southwark Foundry and Machine Company of Philadelphia for the replacement of the old engine and pumps located in the Engine House. The firm was to install new machinery consisting of four tubular boilers, two 27-inch centrifugal pumps and two 18-inch by 18-inch vertical engines. A new cast iron discharge culvert was also included in the contract.[72] The old culverts were overhauled and their entrances repointed. The new pumps were operating by October 1892.[73]

In 1895 the Dry Dock's wooden turning gates were still in use as is evidenced by the fact that they were repaired so that the floating gate could be removed for overhaul. The subsequent repairs to the caisson included recaulking the seams along the keel, the renewal of defective sheeting, hemp gaskets, valves and other fittings, and the overhaul of the furnace boilers.[74]

An act passed June 7, 1900 approved the construction of a "new caisson for the stone dry dock." The appropriation made was $49,800.00 and construction took place in the following year. (See Illustration No. 26.)[75] Although this steel caisson has been rebuilt it remains in use today.

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72. Boston Navy Yard, Annual Report 1890, Record Group 171, Records of Bureau of Yards & Docks, National Archives, Washington. Also Drawing "Proposed Arrangement for Pumping Plant for Boston, January, 1891," Archive, Boston National Historical Park, Charlestown Navy Yard.

73. Boston Navy Yard, Annual Report 1894, Record Group 171, Records of Bureau of Yards & Docks, National Archives, Washington.

74. Boston Navy Yard, Annual Report 1896, Record Group 171, Records of Bureau of Yards & Docks, National Archives, Washington.

75. Boston Navy Yard, Annual Report to the Secretary of the Navy, (Washington: Government Printing Office, 1902).

The drainage system for Dry Dock 1 remained virtually intact until the turn of the 20th century. At that time the Navy began construction of a second stone graving dock at the Navy Yard in Charlestown. Located east of Dry Dock 1, Dry Dock 2 was completed in 1905. The pumphouse for the new dock was located east of both docks and when construction was nearly complete the old culvert opening in Dry Dock 1 was enlarged to 4 feet by 8 feet and was connected to the new pumphouse. The engines and pumps in Building 22 were no longer used to drain the Dry Dock.[76]

Several other minor changes were made to Dry Dock 1 between 1900 and 1945. In 1904 the stairways in the exterior wing walls of the Dock were removed.[77] This was probably done to facilitate the construction of Pier 2, completed in 1906. In 1905 it was proposed that electric capstans be positioned in concrete pits at each side of the Dry Dock over the wing walls and at the center of the head of the Dock.[78] It is possible that these capstans were not actually installed until 1919.[79]

Between 1926 and 1930 the keel blocks were replaced with wooden blocks on concrete bearers.[80] Several proposals were made between 1900 and 1940 to alter the timber slides at the head of Dry Dock 1. Apparently, however, this was not

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76. Drawing "Culvert Between Dry Docks at U.S. Navy Yard Boston, Location Plan and Details." Maintenance Files, Charlestown Navy Yard, Boston National Historical Park.

77. Drawing "Plan Showing Stairs at Outer End to be Removed," Maintenance Files, Charlestown Navy Yard, Boston National Historical Park.

78. Drawing "Plan Showing Electric Capstans for Dry Dock No. 1, Jan. 9, 1905," Maintenance Files, Charlestown Navy Yard, Boston National Historical Park.

79. Drawing "Capstan Pit Covers & Foundation," April 26, 1919. Maintenance Files, Charlestown Navy Yard, Boston National Historical Park.

80. Drawing, "Rearrangement of Keel Blocks on Concrete Bearers," June 5, 1930. Archives, Boston National Historical Park, Charlestown Navy Yard.

done until 1941 when the slide was cut out at either side to allow the shifting of vessels. The slide was also cut back so that the Dock could accommodate a ship of up to 374 feet in length.[81]

One final note should be made concerning repairs made to Dry Dock 1 during this period. The caisson was rebuilt in 1942.[82]

EXTENSION OF DRY DOCK 1, 1947

A quarterly inspection of Dry Dock 1 in March 1947 indicated that the masonry sidewalls of the Dock had undergone significant movement. (See Illustration No. 15.) On the west wall repointing was necessary in the top five altars. Some of the granite blocks needed resetting as well. The side walls had bulged towards each other at the stairwells in the center of the Dock. The most severe displacement had occurred on the west wall between the coping and the fourth altar where some blocks had moved up to 4 inches out of alignment and were in need of both resetting and repointing. On the east the displacement was less severe.

Because of the condition of the Dock masonry and the need for a docking facility of greater size, a second extension of the Dry Dock was undertaken. (See Illustration Nos. 16-20.) It was through this extension that Dry Dock 1 was increased to its present length of approximately 404 feet. Unfortunately, there is little documentation of the changes made to the Dry Dock at this time. It is evident from photographs that the granite side walls were taken down and areas were replaced with reinforced concrete. The granite wing walls were removed as the Dock was extended seaward. Bulkheads of steel sheetpiling were then driven at the new entrance of the Dock. The additions to the side walls at the extension were completely rein-

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81. Drawing, "Dry Dock No. 1, Proposed Alteration at Head, October 17, 1940." Archives, Boston National Historical Park, Charlestown Navy Yard.

82. Drawing, "Casson, Dry Dock No. 1 Repairs, July 14, 1942," Maintenance Files, Charlestown Navy Yard, Boston National Historical Park.

forced concrete. Reconstruction of the side walls was also undertaken closer to the head of the Dock. In these areas the existing granite walls were relaid after the existing rubble backfill was replaced with a row of steel sheetpiles and reinforced concrete backfill. The new work extended from the coping to elevation 97.3; Altar 4. Below this line pressure grouting was used to consolidate the rubble masonry.[83] At this time the granite mitre sill of the Dry Dock floor was also partly removed and replaced with a 6 inch concrete floor lining. In the area of the turning gates a new 18 inch concrete floor was poured and propeller pits were built into this area. Capstans were repositioned over the steel sheet pile cells that had been driven on either side of the Dock's outboard end.[84]

RECENT MAINTENANCE OF DRY DOCK 1

Numerous mechanical systems have been installed in Dry Dock 1 in the last thirty years. These included sewage, electricity, compressed air, fresh water, oxygen, and steam.[85] Systems and hardware changed frequently and required constant maintenance.

In 1964 an enginering study indicated that the 1901 caisson was in poor condition. Replacement of the caisson was considered at that time. In fact the regular schedule of tri-annual overhaul of the caisson was halted because it appeared that an appropriation for a new caisson would be forthcoming.[86] Such an

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83. Drawing "Boston Naval Shipyard, Dry Dock No. 1, Rebuild Outer Portion, Sections, Oct. 29, 1946." Maintenance Files, Charlestown Navy Yard, BNHP.

84. Drawing, "M238 Steel Sheet Piling, Dry Dock No. 1, Reconstruction of Outer Portion, May 19, 1947." Maintenance Files, Charlestown Navy Yard, BNHP.

85. Maintenance Files, Charlestown Navy Yard, BNHP.

86. "Preliminary Engineering Report, Improvements to Dry Dock 1, Boston Naval Shipyard," Maintenance Files, Charlestown Navy Yard, Boston National Historical Park.

appropriation was not made and the Navy resumed maintenance of the caisson until the Navy Yard was disestablished. The National Park Service has continued this program of maintenance. The caisson was completely rebuilt in 1977.

An engineering inspection of Dry Dock 1 completed in the spring of 1979 indicated that the structure is, for the most part, in excellent condition. The granite blocks are in need of some cosmetic repairs and repointing may be necessary.[87] A general program of maintenance should allow Dry Dock 1 to function as originally intended well into the future.

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87. Christopher J. Foster Inc., "Investigation and Evaluation of the Water Seepage Occurring in Dry Dock No. 1." Typescript. Denver Service Center, March 1979.

Chapter 2: Loammi Baldwin (1780-1838)

The Baldwin family of Woburn, Massachusetts made great contributions to the field of civil engineering in North America during the eighteenth and nineteenth centuries. The numerous works of this family of engineers are significant, not only in themselves but because they are illustrative of the development of civil engineering as a profession during this period. This paper will focus on the life and works of Loammi Baldwin II (1780-1838). Any study of this man, who has been referred to as the "Father of Civil Engineering," should be prefaced by brief remarks concerning his father and his brothers, also engineers. The Baldwins were involved in most of the important engineering projects undertaken in New England during their lifetimes. Their involvement in such projects extended from the late eighteenth century with the work of Loammi Baldwin Sr. (1744-1807), most famous for his Middlesex Canal project, to the work of Loammi's brother George Rumford Baldwin (1798-1888), known for his Quebec Waterworks and the development of the South Boston Flats.

Loammi Baldwin Sr. was born in 1744 and lived until October 1807. The elder Baldwin was interested in practical science at a young age and he, along with Benjamin Thompson (later Count Rumford) experimented in the nature of light, heat, and electricity.[1] Baldwin carried on business as a joiner and shopkeeper but received greater recognition as a surveyor. After the outbreak of the Revolutionary War, Baldwin was commissioned as a colonel by the Continental Congress and was called upon to use his engineering skill in constructing fortifications in Boston harbor.[2] After the war Baldwin became one of the directors

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1. Abbott, "Loammi Baldwin," p. 7.

2. Ibid., p. 13.

of a joint-stock company formed to build a bridge across the Charles River in Boston. He also served as consulting engineer on the project. Upon its completion in 1786 the Charles River Bridge was the longest bridge in the world and was considered a great feat of engineering.[3]

In 1794 Loammi Baldwin I helped make the surveys for the Middlesex Canal and in October 1794 he was appointed to superintend its construction. Completed in December 1803, the Middlesex Canal was described by Baldwin as "a narrow, shallow ditch, twenty-eight miles in length, thirty feet wide at the surface, twenty at the bottom and three feet deep, including in the distance twenty locks, eight aqueducts and forty-eight bridges."[4] The canal extended from the Merrimack River to the mill pond at Charlestown, Massachusetts. The elder Baldwin is also credited with popularizing the Baldwin apple as well as having been one of the first to propose that a navy yard be built at Charlestown, Massachusetts.

Baldwin's sons assisted him in surveying and constructing the Middlesex Canal. All of them, Loammi II, James Fowle, George Rumford, and Benjamin Franklin, became engineers, surveying for numerous canals, railroads, and water projects. Benjamin died at a young age. James did many railroad surveys, including early ones for a railroad from Boston to the Hudson River. George Baldwin became an accomplished engineer. His most impressive projects include designs for the Boston Marine Railway and the Quebec Waterworks and plans for the development of the South Boston Flats.[5]

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3. Ibid., p. 23.

4. Ibid., p. 34.

5. Works Progress Administration, "Guide to Manuscript Collections in Michigan, Michigan Historical Records Survey," vol. 2, 1942, p. 64.

Loammi Baldwin Jr., however, was the son destined to follow in his father's footsteps. He carried on the work begun by the opening of the Middlesex Canal, surveying for and constructing canals throughout the eastern United States. Although his canals were important, Loammi Jr's most significant contribution were the Dry Dock projects that he constructed at Norfolk, Virginia and Charlestown, Massachusetts under the direction of the United States Government.

Loammi Baldwin II was born in Woburn, Massachusetts on May 16, 1780. After 1792 he enrolled at Westford Academy, and entered Harvard College in 1796. He earned his degree in 1800.[6] While in school Loammi II assisted his father in his engineering projects, and in 1799 he spent some time teaching school in Chelmsford, Massachusetts.[7] At one time the elder Baldwin, noting his son's interest in math and science, made inquiries concerning the possibility of his son studying "for a year or two with some gentleman in the mathematical line of business in Europe, who is actually in the occupation of making and vending mathematical and optical instruments in an eminent degree."[8] The terms of such service were not agreeable to the father. As a result, Loammi II entered the law office of Timothy Bigelow in Groton, Massachusetts. In 1800, while living in Groton, the younger Baldwin designed and built a fire engine that is in the collection of the local historical society. Baldwin stayed in Bigelow's office for three years, then opened his own office in Cambridge.[9] Throughout this period he remained active in his father's engineering projects.

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6. Abbott, "Loammi Baldwin," p. 59.

7. Ibid., p. 60.

8. George Vose, A Sketch of the Life and Works of Loammi Baldwin, Civil Engineer, (Boston: Press of George H. Ellis, 1885). Hereafter cited as Vose, Baldwin.

9. Abbott, "Loammi Baldwin," p. 61.

Plans for a navy yard to be established at Boston were first presented to the federal government by Loammi Baldwin I and James Sullivan. The site was approved in 1800. In 1804 Loammi Baldwin II presented a detailed analysis for a dry dock project and other improvements to the navy yard in a series of articles that appeared in Boston's Columbia Centinel. Baldwin argued that such a project would benefit the general public as well as the city and port of Boston. The dry dock scheme illustrated Baldwin's early interest in internal improvements and his belief in the necessity of public support of a nationwide system of roads and canals. He felt strongly that such a system could only benefit all concerned and that it would improve the health of the new republic. Baldwin included dry docks in a system of internal improvements because a strong navy was essential to the protection of a country so dependent on commerce. The 1804 dry dock proposal is significant because it shows Baldwin's early interest in the type of construction in which he would pioneer and make his most important contributions to engineering in America.

The scheme, as proposed by Baldwin, was to construct docks

> in Charlestown, a little above the Charles River Bridge, between that and Prison Point. By making a dam at Lechmere's Point to the Charlestown Shore, meeting it perhaps at Harris' wharf, an extensive pond or reservoir will be formed, which will be of great consequence, as will appear hereafter. This dam will cross the channel of a dock near the Charlestown shore. Another dam must be erected from this great one, and joined with it on the west side of the creek, running North until it joins the shore towards the state prison. Here by a dam on the South, another on the West and the high curved land on the North, a triangular basin or inclosure will be formed, in which the docks are to be built, with a common outlet at the channel, through guard-gates in the great dam. [10]

Baldwin's proposal included, not only several docks, but also workshops, sail-lofts, magazines, lunber rooms, ropewalks and other factories, and housing for the workers. Baldwin stressed that all of these improvements would be for

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10. Loammi Baldwin, Thoughts on the Study of Political Economy (1809), (New York: Augustus M. Kelly, 1968), p. 83. Hereafter cited as Baldwin, Political Economy.

the public welfare. They would strengthen the Navy and, therefore, improve the nation's trade, transportation, and communication. Baldwin's plan was an ambitious one. William Gray, merchant of Salem, in assessing the proposal, remarked, "I should rejoice to see the plan executed, but I think that it is too vast for the fortunes of this country."[11] Only one portion of the dry dock proposal was actually constructed and that was Craigie's or the Canal Bridge from Barton's Point in Boston to Lechmere Point in Cambridge.[12] Overwhelmed by his interest in engineering through his work on the dry dock proposal, Baldwin decided to take up that profession. In the summer of 1807 he closed his Cambridge law office and journeyed to England to study and survey the public improvements that had been undertaken there.

Baldwin was unable to visit the continent on his first trip abroad but benefited from an examination of British dry docks and canals although he considered them inferior to the Middlesex.[13] He returned to America on the eve of publication of Secretary of the Treasury Gallatin's famous Report on Roads and Canals that suggested public sponsorship of internal improvements. Gallatin's report developed some of the ideas that Baldwin had expressed in his dry dock proposal. In 1809 Baldwin wrote Some Thoughts on Political Economy in Relation to Population, Industry and Paper Money. In this book Baldwin argued for a nationally subsidized system of public improvements. He stated that "easy communications between commercial towns and new settlements are mutually advantageous," and that a nationwide system of canals and roads would lead the nation to greater prosperity.[14]

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11. Abbott, "Loammi Baldwin," p. 67.
12. Ibid., p. 67.
13. Ibid., p. 70.
14. Baldwin, Political Economy.

In 1812 Baldwin opened an office in Charlestown, Massachusetts. In that same year he undertook one of his few architectural projects, designing and superintendenting the construction of Holworthy Hall. The cost of the new "college" or domitory was $25,000 and was paid for by public lottery. Holworthy Hall has been described as the first "modern dormitory at Harvard, eliminating the medieval study cubicles previously prevailing."[15] In 1814 Baldwin constructed fortifications on Noddles Island in Boston Harbor. The project took two months, and the fort was named Fort Strong on October 26, 1814.

In the next several years Loammi Baldwin undertook a series of canal surveys. In 1814 he travelled to Kentucky to survey for a canal projected around the falls of the Ohio River near Louisville (see Illustration No. 35).[16] He and his brother Benjamin Franklin Baldwin were also appointed to conduct a survey for the Roanoke Navigation Company in North Carolina.[17] The state of North Carolina offered Loammi a position that he accepted. But he continued to work on projects in New England, travelling a great deal between jobs. In 1816 the Massachusetts legislature voted to conduct a survey for the extension of the Middlesex-Merrimack Canal system into the interior of New Hampshire. Baldwin undertook the survey while in New England.[18] In that same year the state of Virginia, instituting a new system of public improvements, appointed Baldwin chief engineer for the state of Virginia.[19] As evidenced by the Annual

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15. Harvard University, Education, Bricks and Mortar (Cambridge: Harvard University Press, 1949), p. 72.

16. Abbott, "Loammi Baldwin," p. 88.

17. Ibid., p. 89.

18. Ibid., p. 91.

19. Ibid., p. 97.

Reports of the Virginia Board of Public Works, Baldwin was recommended for the post by Daniel Webster, Josiah Quincy, and Thomas Jefferson.[20] In accepting the position in May 1816, Baldwin described some of his experience and the qualifications that he felt a state engineer should have:

> I feel honored by the responsibility that has been given me. While in law I was always studying engineering. . . . In September of 1814 I built the fortifications in Boston Harbor, completed them in two months and received a certificate of honor from the Board of War for the work. In November I went to Kentucky to survey the ground for a canal around the falls of the Ohio. But I am under no obligation to continue with that job if Kentucky decides to built it. I am now employed by the General Court of Massachusetts to survey for a canal in New Hampshire. I shall finish that immediately and then go to North Carolina to survey for the Roanoke Navigation Company the Yadkin, Neuse and Tae Rivers for improvements in inland navigation. En route I will pass through Richmond in September and see the gentlemen of the Virginia Board then. . . . You must be sure to employ a man of good character and not a schemer, one who knows natural philosophy, practical machines, hydraulics, hydraulic architecture, etc. and should then be well paid. If I am competent to be it you may decide. If you do not think so you can dismiss me. But once I begin I will not want to leave a work not completed.[21]

Baldwin took the oath of office as chief engineer for the state of Virginia on February 5, 1817 with a salary of four thousand dollars a year. His duties were "to survey and report on routes for canals and opening the navigation of rivers." Baldwin held this office for just over a year, returning to Massachusetts in 1818 at the invitation of the Commonwealth to make a new survey for the Cape Cod Canal.[22] In his final report to the Virginia board, published in the North American Review, Baldwin made another strong plea for internal improvements and for the support of the profession of civil engineering in America. Citing the lack of a scientific approach as responsible for the poor state of the

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20. Copies of letters found in coorespondence file in the Baldwin Collection, Institute Archives, M.I.T.

21. Abbott, "Loammi Baldwin," pp. 95-96.

22. Ibid., p. 106.

profession, he suggested that a central engineering library be instituted, and that experimental work in the field be carried out "all for the benefit of the public good."[23] Prior to 1830 there were no schools of engineering in the United States. The only way to enter the profession was to serve an apprenticeship with a prominent engineer. Unfortunately, as Baldwin pointed out, many practitioners had little training and a wealth of erroneous information. Baldwin advocated a state sponsored program of education to train the professionals needed to carry out the system of national improvements he envisioned.[24]

When he returned to Massachusetts Baldwin began the survey for the Cape Cod Canal. He also accepted the position of superintendent of construction for the Boston and Roxbury Mill Dam Corporation replacing Uriah Cotting who died while the work was in progress. As stated in the corporation's original charter the Mill Dam project was

> to build a dam from the end of Beacon Street at Charles Street to Seawall's Point in Brookline and a cross dam from Gavelly Point in Roxbury to the main dam, to build a road over each dam and to charge toll, also to build a road from the west end of the main dam to the Punchbowl Tavern in Brookline and to confine tide-water within the area bounded by the mill dam and the land, and to build mills to be run by the waterpower so erected or to lease waterpower.[25]

The main dam was described in 1830:

> This splendid work was projected by Mr. Uriah Cotting, who, with others associated, received an act of incorporation, June 14, 1814, under the title of The Boston and Roxbury Mill Corporation. It was commenced in 1818, under Mr. Cotting's direction, but he did not live to witness its completion. His place was supplied by Colonel Loammi Baldwin and the road was opened for passengers July 2, 1821. This Avenue or Mill Dam leads from Beacon Street in Boston, to Seawall's Point in Brookline, and is composed of solid materials water-tight, with a gravelled surface, raised three or four feet above high-water mark. It is one mile and a half in length, and a part of the way 100 feet in width. The water that is now admitted is rendered subservient and manageable.[26]

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23. Ibid., p. 104.

24. Ibid., p. 105.

25. Ibid., p. 106.

26. Edward Shaw, Civil Architecture, (Boston: by Edward Shaw & William F. Stratton, 1830), p. 25. Hereafter cited as Shaw, Civil Architecture.

Actually the mill dam failed to provide enough water power to make the mills profitable, but transportation and communication between the city and adjacent areas were greatly facilitated by its construction. Shortly after the Mill Dam was completed Loammi Baldwin was traveling south to Pennsylvania, having received the appointment of engineer for the Union Canal from the Directors of the Union Canal Company of Pennsylvania.[27]

The Union Canal Company was incorporated in 1811, and work to open a canal between Philadelphia and the Susquehanna River began at that time. A lack of capital delayed completion of the project and the work came to a standstill in 1819. At that time the state of Pennsylvania established a policy of state-supported public improvements. The state coupled its funds with private capital in a mixed enterprise to complete projects beyond the capability of the private sector. The reorganization of the Union Company along with state funding allowed work on the canal to continue under the direction of Baldwin in 1821.[28]

Baldwin began his survey for the canal at Lebanon, Pennsylvania on October 4, 1821.[29] His period of employment began agreeably without a trace of the discord that would eventually cause him to sever his connection with the Union Canal.[30] Construction on the canal began at the end of the year. A a problem soon arose concerning the source of the water needed at the construction site. The solution proposed by Baldwin was not immediately accepted by the directors of the company. Differences of opinion interrupted the work again early in 1822. However, the first serious dispute between Baldwin and the directors concerned the actual route of the canal. The directors hired William Strickland and another engineer to "confer" with Baldwin and to check his survey. Baldwin wrote to a friend concerning the incident saying,

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27. Abbott, "Loammi Baldwin," p. 107.

28. Ibid., p. 109.

29. Ibid., p. 110.

30. Ibid., p. 111.

> The news went through me like a bullet. I cannot tell you the insult this is to my reputation. All right if they approve or disapprove, but instead they went over the same ground and made the survey at the same time to check on me. Insulting to my skill and intelligence, and to me this is dishonorable and vindictive.[31]

At this point Baldwin offered his resignation to the Union Company. It was not accepted and Baldwin decided to stay on temporarily. Rather than improving, however, the situation between the engineer and the company continued to deteriorate. The final blow was the submission of a design for the canal locks by Mr. Mifflin, the president of the Union Company. Baldwin's plan called for locks measuring twelve and a half feet in width, "the proper scale needed for the large scale trade expected."[32] In the spring of 1822 Mifflin submitted plans for locks eight and a half feet in width drawn by William Strickland after several English examples. Baldwin declared that the design was inferior and felt that his powers as engineer were being usurped. His association with the company was ended January 7, 1823.[33] Only five years later the canal locks were found to be of insufficient width to allow the Union canal to become a part of the statewide canal system and they were rebuilt to Baldwin's original specifications.[34]

When Baldwin left Pennsylvania he was offered a position with the state of Virginia. Exhaustion over the Union Canal controversey was compounded by the deaths of his wife and only son. He chose instead to travel abroad before returning to work. Baldwin arrived in Liverpool on April 18, 1823, "to inspect

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31. Ibid., p. 114.

32. Ibid., p. 117.

33. Ibid., p. 126.

34. Ibid., p. 120.

Canals, docks, and manufacturers in England and France."[35] In London he wrote, "the docks are truly noble works. I have examined some of the dry docks along the river where the merchant ships are repaired. Their construction is very simple and might be built at Boston at little expense. I have no doubt they would be found useful."[36] Baldwin was disappointed in France as a country although he found French masonry works superior to English. By contrast he enjoyed Holland and inspected the docks at Antwerp before returning to England.[37] Baldwin took the opportunity to acquire numerous technical books while he was in Europe, building a fine engineering library that survived nearly intact until the present day.

In April 1824 Baldwin returned to Boston. Well-rested and well-informed on European engineering projects, the engineer was prepared to become involved with several important projects. These were to include the designing of the Bunker Hill Monument and, his most significant works, the dry docks which he designed and constructed for the government of the United States.

THE BUNKER HILL MONUMENT

In February 1825 Baldwin was commissioned to do the survey for a canal connecting the Hudson and Connecticut Rivers in conformity to resolutions passed by the legislature of the Commonwealth of Massachusetts "to ascertain the practicability of making a canal from Boston Harbor to the Connecticut River and of extending the same to some point on the Hudson River in the state of New York in the vicinity of the junction of the Erie Canal with that river."[38] The following summer the engineer took time out from this canal survey to help determine the design of a monument to commemorate the Battle of Bunker Hill.

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35. Ibid., p. 129.

36. Ibid., p. 131.

37. Ibid., p. 132.

38. Loammi Baldwin, Report of the Commissioners of the State of Massachusetts, on the Routes of Canals from Boston Harbour to the Conneticut and Hudson Rivers, (Boston: True & Green, State Printers, 1826), p. 5.

The process to select an appropriate design for the Bunker Hill Monument was begun in January 1825. At that time the directors of the Bunker Hill Monument Association chose a Board of Artists with Gilbert Stuart, Washington Allston, Daniel Webster, George Ticknor, and Loammi Baldwin as members.[39] The Board placed advertisements in the Boston newspapers on January 17, 1825 requesting designs for "a monumental column of about 220 feet; to be built of hewn granite." The competition prize was $100. Over fifty designs were submitted including one of an obelisk by Robert Mills of Columbia, South Carolina.[40] Horatio Greenough submitted a model of an obelisk along with a letter explaining why the form of an obelisk rather than that of a column was appropriate.[41] The Board of Artists agreed with Greenough, but his entry was never declared the official winner and the premium of $100 was never awarded.[42]

In May 1825 a second committee was appointed to compare the cost of an obelisk with the cost of a column. This report was presented to the directors on June 2, 1825. Later that month the Board of Directors of the Bunker Hill Monument Association decided that the monument would be built in the form of an obelisk.[43] They proceeded to appoint another committee "to report a design of an obelisk or pyramidal structure and to consider and report on the subject generally." This committee was made up of Loammi Baldwin, George Ticknor, Washington Allston, Samuel Swett, and Jacob Bigelow.[44]

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39. George Washington Warren, The History of the Bunker Hill Monument Association, (Boston: James Osgood & Co., 1877), p. 135. Hereafter cited as Warren, Bunker Hill Monument.

40. Charles W. Snell, "Historic Structure Report, Bunker Hill Monument 1818-1916, Historical Data on its Physical History," Denver Service Center, National Park Service, draft, 1977. p. 32. Hereafter cited as Snell, "Bunker Hill Monument."

41. Ibid., p. 34.

42. Warren, Bunker Hill Monument, p. 158.

43. Snell, "Bunker Hill Monument," p. 36.

44. Warren, Bunker Hill Monument, p. 168.

Loammi Baldwin was made chairman of the third committee. As stated by George Washington Warren, Baldwin was "chairman of this important committee to whom was referred the general subject of the plan of a monument, to be in the form of an obelisk or some pyramidal structure." Warren also gives the following explanation of the younger Baldwin being given the title Colonel which had been held by his father:

> In the records he is more commonly named as Colonel Baldwin, though he was never commissioned with any militia title; but from his professional eminence, and his noble personal bearing, the title was put upon him by a sort of popular authority and it became part of his name...or he might have inherited the title from his father who really was a colonel in the Revoluntary Army.[45]

In order to determine the proper proportion for the obelisk, Baldwin took the committee to the Roxbury Mill Dam where he went through the following process, also described by Warren:

> ...across the then vacant space, the surface of Bunker Hill could be seen; and he fastened against the railing of the sidewalk, in turn, miniature models he had prepared of different proportions, and then, going to a sufficient distance in the opposite direction, so that the model would appear to the eye to be transferred to the hill, as if standing thereon in full size, he would study with them its effects as seen as a distance.[46]

The details and style of the interior construction of the monument were left up to Baldwin as chairman of the committee.[47] Baldwin wrote a detailed report on his design which was presented to the Board of Directors July 1, 1825 (see Appendix E). On July 5, 1825, the plan was adopted unanimously.[48]

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45. Ibid., pp. 181-82.

46. Ibid., p. 182.

47. Ibid., p. 183.

48. Ibid., pp. 189-90.

Loammi Baldwin resigned from the building committee for the monument on August 8, 1825 because of his busy schedule and a regulation made by the directors that made the architect responsible for cost overruns on the construction site. On October 17, 1825, Solomon Willard was appointed architect and superintendent of the construction of the Bunker Hill Monument. He held this position until July 23, 1843, when the monument was finally completed.[49]

Willard did make several changes to the Baldwin plan. Advances in quarrying techniques allowed larger stones to be used than those projected by Baldwin. As a result Baldwin's 147 courses were reduced to seventy-eight. Willard also executed a finer dressing of the interior stones than Baldwin had suggested.[50] In spite of the small changes made by Willard and his years of gratuitous service for the Bunker Hill Monument Association, the credit for the actual design of the Bunker Hill Monument must be given to Loammi Baldwin.

Baldwin completed his survey for the canal to the Hudson River in the fall of 1825. Baldwin's survey suggested that a tunnel be built through Hoosac Mountain in the Berkshires. Before the end of the nineteenth century this project was undertaken for the construction of a railroad rather than a canal.

Early in 1826 Baldwin journeyed to Harrisburg, Pennsylvania to survey a canal for the Harrisburg Canal, Fire Insurance, and Water Company. This canal was for navigation, to supply the city with water from the Susquehanna, and to provide the waterpower for factories and mills to be erected there."[51] Disputes arose in the legislature between the Union Canal Company and the Harrisburg people

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49. Ibid., pp. 190-91.

50. Ibid., pp. 204-205.

51. Abbott, "Loammi Baldwin," p. 148.

and Baldwin left the project in May. He returned to Massachusetts where he did a preliminary survey for the Salem Mill Dam Corporation. The engineer had also been corresponding with Secretary of the Navy Samuel Southard concerning a dry dock project to be built at Charlestown, Massachusetts and this project promised to take up most of his time.[52]

THE NAVAL DRY DOCKS

In 1825 Baldwin was called to Washington at the request of the Navy Department to discuss the construction of a naval dry dock as authorized by Congress on May 25, 1824. Baldwin surveyed various sites for such construction and submitted a preliminary report to the Navy Board in March 1825.[53] In June 1826 Baldwin was appointed to undertake a survey to determine the exact site for the dry dock. On June 30 he wrote to the secretary of the navy, "I can begin August 1."[54]

In August 1826 Baldwin began detailed surveys and estimates for the construction of dry docks at the navy yards in Portsmouth, New Hampshire, Charlestown, Massachusetts, Brooklyn, New York and Norfolk, Virginia. He was assisted by his brother George Rumford Baldwin. Reports on each of the four yards were submitted in January 1827 and in March, Congress authorized the construction of two dry docks, one at Charlestown, the other at Norfolk.[55] Secretary Southard then informed Baldwin that President Adams was in favor of his appointment as engineer for the construction of the docks. The engineer accepted the appointment on the conditions that he be given full authority over the project and that he be able to employ his brothers as assistants.[56] An elaborate plan was prepared

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52. Ibid., pp. 151-52.

53. Ibid., p. 139.

54. Ibid., p. 153.

55. Ibid., p. 154.

56. Ibid.

including many of the facilities suggested in "Observations on Dry Docks" (1804). In developing this overall plan Baldwin was technical advisor in the gradual improvements of navy yards provided for in the Act of Congress passed March 3, 1827. As stated in the resolution, it allowed "for the gradual improvement of the Navy of the United States, two dry docks, one North and one South of the Potomac, a marine railway at Pensacola, Florida, and the general improvement of the Navy Yards." Baldwin was to serve as civil Engineer for the government and in this capacity have a hand in all of these projects.[57]

Baldwin met with the Navy Board of Commissioners in May 1827 to complete the details of the dry dock construction. Baldwin, dividing his time between the two docks, had hoped to appoint his brothers James and George as assistant engineers. Because James was too busy, however, and George was ill, Baldwin appointed Henry Singleton to superintend construction at Norfolk. He chose Alexander Parris, a former student of his and architect of Boston's Quincy Market (1826) to oversee the work at Charlestown.[58]

Surveys and contracts were made, and Baldwin spent a good deal of time selecting the best machinery and materials for the job. The directors of the Middlesex Canal agreed to supply water to the construction site.[59] Contracts for the granite and foundation store were made with Gridley Bryant as agent for the Granite Railway Company in Quincy, Massachusetts. The pumps used to drain the works while building were invented by Ebenezer Lester[60] and manufactured by Lazwell Perkins of Bridgewater, Mass. After much experimentation Baldwin chose Roman cement over the domestic varieties used in hydraulic masonry.[61]

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57. Ibid., p. 155.

58. Ibid., p. 156.

59. Ibid.

60. Contract between U.S. Government and Gridley Bryant, Baldwin manuscripts, Baker Library, Harvard University.

61. Abbott, "Loammi Baldwin," pp. 157-58.

By November 1827 work at Charlestown was already in progress on the pier, wharves, and cofferdam. Progress at Norfolk was not as rapid. In 1828, however, both docks were well underway. A school to educate engineers was established at each of the docks. The students at each site benefited from Baldwin's expertise, his excellent library, and the novel character of the dry dock projects. "My terms on receiving a student," Baldwin wrote, "are two hundred dollars a year. When I can employ them at times they received a dollar a day at Charlestown, a dollar and thirty-two cents at Norfolk."[62]

In 1827 Baldwin was officially appointed consulting engineer to the Navy's planning board. As such he travelled widely and worked on many projects including the marine railway at Pensacola and a survey of Governor's Island in New York Harbor.[63] In the meantime Baldwin also agreed to prepare plans for the Warren Avenue Bridge Corporation for a bridge across the Charles.[64]

By the summer of 1829 the excavation of the docks had been completed and foundation piles driven. Baldwin estimated that the docks would be complete "2 years from next spring."[65] Minor problems did occur delaying progress in construction. These included intoxification of workmen, the difficulty of operating pile drivers powered by tread wheels, and labor difficulties prompted by the hiring of blacks. A committee of stone-masons and concerned citizens in Virginia forwarded a petition to President Jackson stating the following:

> On application by us for employment we were refused in consequence of the subordinate officers hiring negroes by the year under the immediate cognizance of the chief engineer and placing them at stone cutting for which they are entirely incompetent to the injury of we the undersigned who are competent and skillful workmen and men of families.

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62. Ibid., p. 162.

63. Ibid., pp. 162-63.

64. Ibid., p. 166.

65. Ibid.

Baldwin was asked to make an explanation to the navy commissioners. He responded that he had acted in the best interest of the government in hiring slave labor because "it was cheaper by study to employ slaves in hard labor."[66]

In the summer of 1830 the timber basin, sluice-gate, timber docks and sheds and warehouses were complete at Norfolk. In December the engineer reported that Mr. Ebenezer A. Lester would build the steam engines for the docks. In 1831 Lester supervised the installation of the engines and pumps at both sites.[67] Additional labor problems delayed construction at Norfolk but by the end of 1831 the docks were approaching completion. Just over a year later the Charlestown dock was complete except for the removal of the cofferdam and the trail docking of a ship.[68] When finished the dock was "a huge basin of hewn granite blocks and exact masonry, laid in cement, whose foundation rests on piles on which was laid a massive oaken floor."[69] The dock measured 360 feet in length, 86 feet in width, and 30 feet in depth. As described by Englishman David Sterenson in his Civil Engineering in North America (1838) it was "the finest specimen of masonry that I met in America."[70]

Both of the docks were completed during the spring of 1833. The Delaware was docked in the Norfolk dry dock on June 17, 1833 and the Constitution entered the Charlestown dock a week later.[71] Baldwin turned the Charlestown dock over to the Navy on September 9, 1833.[72]

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66. Ibid., p. 168.

67. Ibid., p. 172.

68. Ibid., p. 178.

69. Ibid., p. 181.

70. David Stevenson, A History of Civil Engineering in North America (London, 1838).

71. Abbott, "Loammi Baldwin," pp. 182-83.

72. Ibid., p. 184.

After the completion of the dry docks, Baldwin was offered the position of Chief of Naval Construction at three thousand dollars a year. Baldwin declined this opportunity perferring to remain in a temporary position with the Navy at the same salary he had received while working on the docks.[73]

A project for a bridge over the Potomac River was reviewed by Baldwin in December 1833. The plans, by O.H. Dribble, had the support of President Jackson. Baldwin critized Dribble's specifications for the Potomac Bridge as unclear and inaccurate. This dispute was the most serious that Baldwin had had with the administration. The government did not move to dismiss the engineer, but did not raise the salary of the permanent position that he had been offered. Baldwin decided not to accept the job because of the low salary.[74] At the time the Navy was considering a new dry dock project to be built at New York. Had the project been begun Baldwin probably would have accepted the job of superintending construction. The project was delayed, however, and Baldwin returned to private practice in May 1834.

BOSTON'S WATER SUPPLY AND OTHER LATER PROJECTS

Until the 1830s most of Boston's water was provided by wells and rain water cisterns. These sources were inadequate to the needs of a growing industrial city. In April 1834 a resolution was passed by the legislature to have a survey made for supplying the city with pure water by means of a canal, pipe, or aqueduct.[75] Baldwin was in charge of this project, along with many others. He served on the

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73. Ibid., p. 188.

74. Ibid., p. 196.

75. Ibid., p. 199.

State Executive Committee under Governor John Davis in 1835 and became chairman of the board for a survey of Boston Harbor (see Illustration No. 37). In 1835 the engineer took a leave of absence from the Commonwealth to do a preliminary survey for the New York dry dock.[76] The President then requested more detailed estimates and plans which were provided by the engineer. It was evident that construction on the dry dock would not begin immediately and Baldwin, disenchanted by the political interference which delayed so many of his plans, left government service permanently in 1835.[77]

In the next several years, Baldwin carried out several surveys for the Penobscot Mills Company in Bangor, Maine. He also surveyed the Androscoggin and Amoskeag Rivers in New Hampshire and sections of the Merrimack River. Baldwin was called upon briefly by the Navy Department to help determine locations for new Navy Yards at Jersey City, Perth Amboy, and Great Barn Island.[78]

Late in 1836 Baldwin made one final contribution to the area of engineering in which he had started his career, canal building. He went to Georgia to begin construction of the Brunswick Canal from the Altamala River to the port of Brunswick. Baldwin was taken ill in April 1837 and returned to Boston. His health improved but not enough for him to continue work in the field. Until his death a year later the engineer worked on surveys on Boston harbor and the Boston and Roxbury Mill Dam.[79] Loammi Baldwin II died June 30, 1838 while these projects were in progress.

Loammi Baldwin's engineering genius survives in several of his projects. The dry dock at the Charlestown Navy Yard is part of the Charlestown Navy Yard, Boston National Historic Park and is kept in operation by the National Park Service. The Norfolk dock is still in use by the United States Navy. The contributions

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76. Ibid., p. 206.

77. Ibid., p. 208.

78. Ibid., p. 217.

79. Ibid., p. 224.

made by the Baldwin s are sometimes difficult to appreciate in a day when travel is not dependent upon canals, railroads, and dry docks. The Baldwins' contributions have not ended. The Baldwin family library is presently held by the Institute Archives at M.I.T. If studied with the Baldwin papers at Baker Library at Harvard, and drawings, maps and maunscripts on deposit at the William L. Clements Library at the University of Michigan, this library provides a unique source of information on the state of the profession of civil engineering in America during the nineteenth century. Through these sources one can trace the development of the profession from eighteenth century when Loammi Baldwin I and Count Rumford carried out their experiments until the last quarter of the nineteenth century when George Rumford Baldwin completed his plans for the Quebec waterworks and the development of the South Boston Flats.

Chapter 3: The Granites Used in Dry Dock 1

Dry Dock I at the Charlestown Navy Yard, Boston National Historic Park, was designed and constructed by Loammi Baldwin II (1780-1838). Baldwin was the foremost civil engineer in New England at the time. He first proposed the construction of the dry docks in America in a series of newspaper articles published in Boston's Columbia Centinel in 1804. It was not until 1824, however, that Baldwin was approached by the secretary of the navy to examine sites and produce designs for an American dry dock like those found in England and on the continent. European dry docks had taken a variety of forms and were built of timber as well as stone. Baldwin firmly believed that public works should be made durable and the docks that he proposed were to be built of masonry.

Building in stone was a limited enterprise in New England until the early years of the nineteenth century. The technology that was available did not allow the efficient quarry of the denser varieties of stone, like granite, that were abundant in the New England states. Stone that was used was generally of the loose surface variety or taken from large boulders. At the turn of the nineteenth century, however, the method of drilling holes into which were driven wedges to split stone from a quarry was applied to the great deposits of granite in the areas surrounding Boston. During the same period the Middlesex Canal, designed by Loammi Baldwin I (1744-1807), and connecting the Merrimack River with Boston Harbor, was completed. Transportation from the granite quarries in Chelmsford, Massachusetts was thereby facilitated, reducing the previously exorbitant price of moving building stone to the city. Chelmsford provided most of the granite used in Boston buildings during the first quarter of the nineteenth century. When construction

of the Bunker Hill Monument began in 1825, the granite quarries at Quincy, Massachusetts were finally put into production. The Quincy stone was thereafter used throughout the northeastern United States for bridges, monuments, and harbor works. The period of granite building lasted until the end of the nineteenth century, when ironically, the growth of the nationwide system of railroads ended the age of canals and water transport. Once again the transportation of building stone on a widespread basis became ecomomically unfeasible.

Dry Dock I was built of Quincy granite. Loammi Baldwin II, the engineer, first submitted a proposal for the granite dry dock at the Charlestown Navy Yard in November 1824.[1] It was not until three years later, however, that the dock was actually under construction. On September 28, 1827, Baldwin placed advertisements in Boston newspapers requesting proposals "for furnishing and delivering granite stones for about 20,000 cubic yards of masonry for the Dry Dock" (see Appendix G). The engineer received several responses to this request. Most were from Quincy quarriers and stone masons. They included one from Gridley Bryant, famous for his design and construction of the Granite Railway, built to transport the stone for the Bunker Hill Monument. Bryant's first proposal was to provide the dry dock stone at $4.00 per cubic yard. Jonathan Newcomb, another Quincy quarrier, entered a bid of $3.60 per cubic yard. Presumably Newcomb would have been awarded the contract but Bryant, learning that not all of the stone was to be finely finished, lowered his original bid to $3.00 per cubic yard.[2] Bryant had made an earlier contract with Baldwin to lay a dry stone wall adjacent to the construction site of the dry dock.[3]

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1. Letter, Loammi Baldwin to Samual Southard, Secretary of the Navy, November 6, 1824. Baldwin MSS., Wm. L. Clements Library, University of Michigan, Ann Arbor.

2. Baldwin MSS. volume 70. Baker Library, Harvard University.

3. Contract between Gridley Bryant and United States Government, July 24, 1827. Baldwin MSS., volume 74, Baker Library.

Because Baldwin was to spend half of his time superintending the construction of the second dry dock for the government at the Navy Yard at Norfolk, Virginia he appointed Alexander Parris as assistant engineer at the Charlestown site. Parris was a former student of Baldwin and the architect of Quincy Market (1826) in Boston. On November 1, 1827, Mr. Stuart J. Parks was engaged as stone mason to superintend the actual laying of the masonry.[4] A week later, on November 9, "Mr. Parris...delivered a sketch of a contract to Colonel Perkins, President of the Railway Company, for furnishing the rough stone for the Dock, and requested him to examine it."[5] On November 10 Baldwin informed the Navy Commissioners:

> Having on the 28 September advertised for proposals, for delivering the stone for building the Dock, to be received until the first of this month, I am now engaged in arranging a contract with Gridley Bryant upon his proposals, upon which he offers to furnish all the stone both for the hammered & rubble work at $3 per cubic yard, & it is estimated that about 20,000 yards will be required.[6]

On November 12, Bryant, as agent for the Granite Railway Company, visited the Dry Dock Office at the Navy Yard and closed the contract for furnishing the stone for the dry dock.[7] Bryant's contract stated the terms upon which he was to provide the stone

> from the Quincy granite quarries, all the dimension and rough stone which shall be wanted for the building of the said Dry Dock, estimated to contain in the whole sufficient for about twenty thousand cubic yards of masonry as the stones shall measure when laid; all the stones for the hammered and Ashlar work, floor courses, Alters, coping, stairs, gate quoins, mitre sill etc. to be split & to be got out conformable

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4. Abbott, "Loammi Baldwin," p. 155.

5. Entry in "Diary kept at the Dry Dock Office, Charlestown," November 1, 1827.

6. Ibid., Entry November 9, 1827.

7. Loammi Baldwin, "Annual Report to Navy Commissioners," November 10, 1827. Baldwin MSS, volume 70, Baker Library, Harvard University.

> to patterns and dimensions which the said Baldwin or other engineer for the time being shall furnish, in a good and workman-like manner, and quarried as near to such patterns and dimensions as such stones usually are quarried for hammering, all the rough stone for rubble work to be split and quarried in such manner, that the bed and build of each stone shall be parallel or nearly so, but not necessarily to be of equal height or depth each with the other, but so that the same may be laid up in good compact banking without hammering. [8]

Delivery of stone was to be made at a wharf in Charlestown below the Charles River Bridge "excepting five hundred cubic yards of the dimension stones including the coping & stair stones," which Bryant was to deliver to the state prison to be hammered, if requested by the engineer.[9] An entry in a "Dairy kept at the Dry Dock Office," dated April 26, 1828, states that "the first freight of Stones for the Dock was delivered today, from the Quincy railway, agreeably to the contract made with Mr. Bryant."[10] On April 30 Mr. Stuart J. Parks, master stone cutter, was placed on the Dry Dock pay roll at $130 per month."[11] Pattern stones, those with finely finished faces were marked with paint so as to be placed properly into the dock construction. Concerning the fulfillment of the contract for the dry dock stone, Gridley Bryant wrote to Thomas Perkins, President of the Granite Railway Company:

> I shall send all the stone that is wanted, Both Ruble & Ham, every freight is measured and settled for as it arrives, & payments made at the rate of 75 cts. on the dollar 25 per cent being reserved for security of Government, as it respects the Charlestown Dock, I presume that the payments I receive are a fair proportion of the quantity and quality of the stones as they are delivered, whether this will be the result when the work is measured I cannot say. Parris & Parks appear to be satisfied that they are not overpaying. [12]

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8. Entry in "Diary kept at the Dry Dock Office," entry, November 12, 1827.

9. Contract between Gridley Bryant and the United States Government, November 12, 1827. Baldwin MSS., volume 74, Baker Library.

10. Ibid.

11. Entry in "Dairy kept at the Dry Dock Office," April 26, 1828, April 30, 1828.

12. Gridley Bryant, Granite Railway Company Agent's Book, April 9, 1830. MSS, Quincy Historical Society.

Apparently the contract for the stone was fulfilled without many problems. Baldwin included the following remarks in his annual report on the state of the dry dock construction to the Navy Commissioners in November 1831:

> Mr. Bryant's contract No. 9 was settled October 29th under the following circumstances. He had nearly or quite delivered all the stone originally contemplated under the contract, and became very anxious to receive some money which I could not pay, as the terms stipulated were that one quarter part should be withheld until the contract was fulfilled. He had a claim for several hundred cubic yards of dimension or pattern stones, over the proportion of 1/4 fixed by the agreement, and as I was about going to Norfolk to be absent several months, I concluded it just and fair to close the contract myself, rather that have it be settled in my absence or delay it till my return. The whole amount of cubic yards is 20541.52. The whole amount allowed was $64838.56. He had been paid $55508.79 which left the balance due on closing the contract $9329.77. But this settlement was made upon the express agreement that he is to provide all the stones wanted for the back course of coping at $8 the cubic yard; and what shall be required for the jettee walls at the entrance of the Dock & for the Drain at $5 & all the rubble stone at $2.50 per cubic yard.[13]

The dry dock masonry was laid upon foundation piles and several layers of heavy timber plank flooring filled with rubble stone and cement. The following description of the stone work for the dry dock at Charlestown was published in the American Magazine of Useful and Entertaining Knowledge in 1835, two years after the dock's completion.

> The masonry commences at the depth of thirty-two feet below ordinary high water, rising four feet above it, and covering an area of one hundred feet wide, three hundred and forty-one feet long....All the faces of the interior masonry of the floor and altars, the faces of the entrance and wing walls, and bottom of the entrance, are of hammered stone work laid in water-proof cement. The bottom courses of masonry over the whole floor, about one foot six inches in depth, as well as one foot six inches in thickness around the whole exterior backing of the dock and entrance, are also laid in cement. In all such parts of the masonry of the dock, where it has been deemed desireable, the courses of stone are so arranged as to form arches, to resist the upward pressure. The

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13. Loammi Baldwin, "Annual Report to the Navy Commissioners," November 2, 1831. Baldwin MSS., volume 69, Baker Library, Harvard University.

whole stonework in the dock amount to five hundred thousand cubic feet."[14]

The mortar used in the construction of the dry dock was made of two parts clean sharp sand and one part of the best hydraulic lime.[15] Baldwin experimented with many hydraulic cements before choosing Roman over the domestic products which he deemed inferior.

As stated earlier, Loammi Baldwin was also the engineer for a dock building at Norfolk, Virginia while he was supervising the Charlestown project. The dimensions of the stones for the Norfolk dock differed little from those used at Charlestown, both docks being constructed from the same plans. The contract agreement for the Norfolk granite did differ, however, in that it was made with Gridley Bryant, Jonathan Newcomb (See Illustration No. 42) and others and, therefore, came from several different quarries.[16] The granite for Dry Dock I at Charlestown was supplied in total by Gridley Bryant and the Granite Railway Company.

THE GRANITE RAILWAY COMPANY

The Granite Railway Company was organized to transport the granite for the Bunker Hill Monument from the quarry in Quincy to tidewater on the Neponset River, a distance of nearly three miles. The Granite Railway has been referred to as the first railroad in America.[17] Whether or not this is true is a matter of dispute, but it is quite possible that the Granite Railway was the first railway

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14. American Magazine of Useful and Entertaining Knowledge, (Boston: Berwick Company, 1835) p. 298.

15. Stuart, Naval Dry Docks, p. 60.

16. Contract between United States Government and Jonathan Newcomb, Joseph Richards, and Gridley Bryant. Baldwin MSS., volumes 70 and 74, Baker Library.

17. Granite Railway Company, The First Railroad in America (Boston: Walton Advertising & Printing Co., 1926). p. 1.

in America to operate as a commercial carrier.[18] It was on this basis that the railway carried the stone from Bunker Hill Ledge. The quarry was operated by the architect Solomon Willard and Bunker Hill Monument Association.

On January 4, 1826, a petition for the incorporation of the Granite Railway Company was filed in the Commonwealth of Massachusetts by Thomas H. Perkins, William Sullivan, Amos Lawrence, Solomon Willard, David Moody, and Gridley Bryant. The petition was granted on March 4. Solomon Willard had examined granite deposits throughout New England in search of a stone suitable for the construction of the Bunker Hill Monument. Having decided on Quincy granite, the architect made arrangements to quarry the stone. Gridley Bryant purchased the Bunker Hill quarry from Frederick Hardwick on June 9, 1825 for $250.[19] Bryant then sold the rights to quarry all of the stone needed for the construction of the monument to the Bunker Hill Monument Association for $325.[20] The actual task of quarrying was to be done by the Association. The Granite Railway was built in 1826 and the first car, drawn by horses, began operation on October 7, 1826.[21] A contract for carrying 3000 tons of stone from Bunker Hill ledge to Deven's Wharf in Charlestown was made March 27, 1827, and the first stone delivery was made in May.[22] The stone was transported from the quarry to the wharf on the Neponset River on the railway, there it was put in flat bottomed boats and towed by steam power to the wharf in Charlestown. From the wharf to the site of the monument the granite was carried by teams of oxen upon an inclined plane of flagstones.[23] Repeated transfers caused significant damage to the stones, and,

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18. Personal interview with Mr. Hobart Holly, Quincy Historical Society, Quincy, Massachusetts. Spring 1979.

19. Granite Railway Company, First Railroad, p. 5.

20. George Washington Warren, Bunker Hill Monument, p. 203.

21. Granite Railway Company, First Railroad, p. 1.

22. Solomon Willard, Plans and Sections of the Obelisk on Bunker's Hill (Boston: Charles Cook, 1843), p. 28. Hereafter cited as Willard, Obelisk on Bunker's Hill.

23. Snell, "Bunker Hill Monument," p. 60.

by September 1828, the Bunker Hill Monument Association had ended its contract with the Railway Company in favor of transporting the granite with carts pulled by oxen.[24] By that time the Granite Railway Company had begun operating its own quarry at Pine Hill Ledge, below the Bunker Hill quarry, and was fulfilling contracts for other important works such as Dry Dock I at the Charlestown Navy Yard.[25]

In laying out the Granite Railway, Gridley Bryant was assisted by George Rumford Baldwin, Loammi's brother.[26] Bryant was responsible for numerous innovations to be used in railroads. These included the eight wheel car, the turn table, the railroad switch, and the portable derrick.[27] Bryant believed that his inventions should benefit the public and, therefore, did not patent his inventions. As a result, during his later years, he expended most of his energy in court battles with those who had patented his inventions in their own names.

Gridley Bryant was born in Scituate, Massachusetts, August 26, 1789. He worked on many of the early public improvements in Boston including Fort Strong on Noddles Island and the Mill Dam, both projects superintended by Baldwin.[28] Bryant lived until 1867. He had a son by the same name, Gridley J. F. Bryant. The younger Bryant was a noted architect and designed many of Boston's granite mercantile buildings. The two Bryants are frequently confused and it should be noted that Gridley J. F. Bryant is listed on the payroll as assistant surveyor for the Charlestown dock in June 1832 where he was paid $1 per day.[29]

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24. Ibid.

25. Thomas N. Dale, The Chief Commercial Granites of Massachusetts, New Hampshire and Rhode Island (Washington: Government Printing Office, 1908), p. 111. Also Warren, Bunker Hill Monument, p. 207.

26. "Profile and Plan for the Granite Railway," undated. Baldwin MSS. map, Wm. L. Clements Library.

27. Warren, Bunker Hill Monument, p. 211.

28. Ibid.

29. Dry Dock Payroll Book. Baldwin MSS. Institute Archives, M.I.T.

The Granite Railway Company's innovative approach to transportation was noted in most of the contemporary publications focusing on the building trade. Edward Shaw described the railway in his book Operative Masonry, published in Boston in 1832:

> The Quincy stones are raised from their beds by means of a windlass marked by a horse, and received upon cars, which run upon inclined rail-ways, within a few feet of the quarry; from thence they are conveyed to the sea on a rail-way at the quarry, an empty car is drawn up.[30]

The original tracks of the railway were of oak but, as noted by Bryant in a letter to Thomas H. Perkins, President of the Railway Company, in 1830 the timber rails did not wear well. He wrote, "The continued wear of the oak on the tracks is unavoidable on account of the disproportion of the loads & the Rail tracks.... Stone tracks might be substituted for the wooded." Regarding the delivery of the stone to the wharf Bryant continued, "we are obliged to take the stone directly to the wharf as soon as quarried, on account of their great weight which cannot be moved at a convenient distance or remain to be taken at our leisure."[31] Bryant described the Granite Railway as follows in 1859:

> ... the deepest cutting was fifteen feet, and the highest elevation above the surface of the ground was twelve feet. The several grades were as follows: the first, commencing at the wharf or landing, was twenty-six feet to the mile, the second thirteen feet, and the third thirty-six feet. This brought us to the foot of the table-lands that ran around the main quarry; here an elevation of eighty-four feet vertical was to be overcome. This was done by an inclined plane, three hundred and fifty feet long, at an angle of about fifteen degrees. It had an endless chain, to which the cars were attached in ascending or descending. At the head of this inclined plane I constructed a swing platform to receive the loaded cars as they came from the quarry. This platform was balanced by weights, and had gearing attached to it in such a manner that it would always return (after having dumped) to a horizontal position;

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30. Edward Shaw, Operative Masonry (Boston: Marsh, Capen, Lyon, 1832), p. 37. Hereafter cited as Shaw, Operative Masonry.

31. Gridley Bryant, "Granite Railway Company Agent's Book." August 9, 1830. MSS., Quincy Historical Society.

> being firmly supported on the periphery of an eccentric cam. When the cars were out on the platform there was danger of them running entirely over, and I constructed a self-acting guard, that would rise above the surface of the rail upon the platform as it rose from its connection with the inclined plane, or receded out of the way when the loaded car passed on the rack; the weight of the car depressing the platform as it was lowered down.

Bryant also constructed a turn table at the foot of the quarry which was still in operation in 1859 as originally constructed. The railroad continued around the quarry at different grades, the highest point reached being ninety-three feet above the base level.[32]

The bed of the Granite Railway was built of crushed granite with stone sleepers spaced at eight foot intervals supporting wooden rails twelve inches high. Where the rails crossed public roads stone rails were used. As the original wooden rails decayed they too were replaced by stone rails.[33] The first car used on the railway was built by Bryant at a cost of $600. It had high wheels which measured six and a half feet in diameter. The load was placed on a platform that was held under the axles by chains. The platform was let down in a convenient place and the car was run over it. The chains attached and the platform was raised above the track by machinery at the top of the car. The average load carried weighed approximately six tons.[34] The Granite Railway Company continued in existance until 1942. Today the Granite Railway Quarry is filled with water and rock climbers practice on its craggy faces.

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32. Granite Railway Company, First Railroad, p. 13.

33. Ibid., p. 15.

34. Ibid.

QUINCY GRANITE AND EARLY METHODS OF QUARRYING

Quincy granite consists of syenite, quartz, feldspar, and hornblende in varying degrees. Depending upon the exact constituents of an individual the stone varies in color from shades of pink to those of green and gray. The Granite Railway Quarry produced a stone referred to as "Quincy dark blue railway." As described by Thomas Dale in The Commerical Granites of Massachusetts, New Hampshire and Rhode Island, this stone is a riebeckite-aegirite granite of dark bluish gray color, and medium to coarse, even-grained texture, with feldspars up to .5 inch and black silicate up to 0.3 inch. Its constituents, in descending order of abundance, are: a dark bluish-greenish gray, black streaked potash feldspar, minutely intergrown with soda-lime feldspar, apparently darkened by microscopic black particles and also somewhat kaolinized. It contains blue-brownish crystals of riebeckite down to 0.009 millimeter long, also irregular particles of green epidate and some slender ones up to 0.37 millimeter long. The railway granite ranges in color from light gray to extra dark and was used primarily for monuments and polished building fronts.[35]

Prior to the turn of the nineteenth century little building in stone was done in New England. The quarrying methods used were quite primitive. One example of this was the quarrying of granite from boulders found on the surface of the ground. Fires were built around the perimeter of the boulder until it was heated. Iron balls were then dropped on the boulders causing them to split.[36] Harley McKee describes the earliest granite quarrying in New England as having been done by German immigrants.

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35. Dale, Commercial Granites, p. 112.

36. Harley McKee J. "Early Ways of Working and Quarrying Stone in the United States," Association for Preservation Technology Bulletin, III, No. 1, (1971), p. 46. Hereafter cited as McKee, "Quarrying."

> During the late eighteenth century a small amount of granite was quarried by blasting at Quincy, Massachusetts, in addition to that found in a detached state; these irregular blocks were squared to the desired size by cutting a groove along a straight line with an adhammer and striking repeated blows on both sides of the groove.

This process was wasteful because oftentimes the stone did not break along the line of the groove.[37]

About 1800 the method of splitting stone by drilling a line of holes and driving wedges into them was introduced in New England.[38] It was this advance in quarrying technology that reduced the waste and the cost involved in getting granite out of a quarry. This was essential if granite was to be used extensively as a building stone in New England during the nineteenth century. The method of using wedges to split stones was described by Edward Shaw in 1832:

> The stones are obtained of suitable dimensions by blasting, by splitting with iron wedges set in a direct line, and driven with much force by a sledge or hammer. Advantage is often taken of natural fissures which are in straight lines, and often at right angles...Granite, and the stones related to it, although of great hardness will split very straight by means of wedges. The pieces are afterwards wrought into the form to be used, either at the quarry, which diminished the cost of transportation, or removed in a rough state, and thus used in building, or finished as may be deemed expedient. [39]

The measure of a master stone-mason's ability was often the expertise with which he could recognize and take advantage of the natural cleavage in the stone. The most prominant cleavage was the rift of the stone and the second was the grain.

Tap stone that was found on the very surface of the quarry often had incipient cracks. The fact that this stone was more accessible was offset by its flaws and as the quarry industry evolved the first step taken in opening a quarry was to strip the cap rock or "overburden." Only the unaffected stone

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37. Ibid.

38. Granite Railway Company, First Railroad, p. 27.

39. McKee, "Quarrying," p. 55.

underneath would then be used. As the industry became more sophisticated there was less emphasis on the accessibility of a particular stone deposit and the quality and durability of the stone became more important.[40] Gridley Bryant noted the superior quality of the stone which lay deeper in the quarry in 1830 saying:

> I have often stated to you, that in every place where the quarry is opened, that the stone grows better as we get in, this still holds good,--I do not mean that there will finally be no rough stone in the Quarry but that the stone grows better, lays in longer, & better shaped masses & of better quality and color, & is worked at better advantage.[41]

As stated earlier, the cost of transporting building stone limited early stone construction to sites adjacent to areas in which stone could be easily obtained. Stone was moved short distances by cart drawn by horses or oxen.[42] If a site was along the coast, transportation was somewhat easier and stone was used in harbor works like seawalls and in bridges. By 1840 the quarrying of granite was a major industry. The methods and tools used, many of them developed by Gridley Bryant and Solomon Willard, remained almost unchanged until the end of the nineteenth century. At that time steam-powered channeling machines, planing machines and pneumatic-powered chisels came into general use.[43]

Once a block of stone had been split from the quarry, or "quarry pitched," it was hammered into the desired size and shape. This process was described by Shaw as follows:

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40. Ibid., p. 54.

41. Gridley Bryant, "Granite Railway Company Agent's Book." August 9, 1830. MSS., Quincy Historical Society.

42. McKee, "Quarrying," p. 44.

43. Ibid., p. 57.

> In working granite, and materials of a similar nature, it is first lined, or marked into the form desired. The workman then forms the edge all round by means of a chisel and hammer, making it smooth and straight to the depth of one or two inches; he afterwards breaks off the larger portions with a hammer made in a peculiar form and kept sharp; with this instrument he continues to take off the inequalities of the surface, till it has the requisite smoothness.[44]

Quarrying tools used in the nineteenth century were not unlike those that had been used since Roman times. A list of some of the apparatus used at the Bunker Hill Quarry in 1827 is probably illustrative of that used in other quarries including the Granite Railway Quarry. The following is a partial list of that apparatus:

Capstans, Chain & rigging
Bellows, Anvils
Tongs
Hand Hammers
Boring apparatus
Sets of Swidges
New Jacks.[45]

Hewing Hammers
Picks
Plug drills and Feathers
Broad Chisels & Points
Plug wedges and half rounds

The mason's pick, shorter and stouter than an ordinary pickax, was used at the quarry for dressing a block of stone to its approximate shape. This was known as "rough hammering." Several other kinds of picks were used to make channels in the stone. Axes were used in surface finishing, a process sometimes called "face hammering." Chisels had a blunt rectangular cutting face and were used to trim the edges of a stone to a straight line. Points were implements with pyramidal-shaped cutting ends. They were used in the initial stages of cutting down the rough surface of hard stone. Drills were used to cut holes into the rock. Two semi-circular iron feathers, or "half-rounds" were then inserted into the hole and a wedge or "plug" was driven between them to split the stone. Hand hammers were used in driving points, chisels and drills.[46]

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44. Shaw, Operative Masonry, pp. 36-37.

45. Solomon Willard, "Letter Book." MSS., Massachusetts Historical Society.

46. McKee, "Quarrying," p. 50.

It would be safe to assume that they were also used by the Granite Railway Company. These included a lifting jack for turning and lifting heavy blocks of stone and the Holmes hoisting apparatus which could lift weights too heavy for shears or derricks.[47] In 1830 Gridley Bryant referred to a hammering machine that had been invented but noted that it lacked an efficient power source. He was, therefore, uncertain as to whether it would ever amount to much.[48] The machinery used at the Bunker Hill Quarry was eventually augmented by others powered by steam. The apparatus developed by Willard and Bryant continued in use nonetheless.

Finally, a letter from Solomon Willard concerning the Wigwam Quarry in Quincy in 1837 provides an excellent account of how the early quarries operated in terms of personnel.

> Since the 1st of December we have done everything in our power to put the Quarry into the best conditions possible.--Our gang consists of about a dozen hammerers, with a Superintendent of the hammering, 1 Carpentar, one tinsman, 4 Blacksmiths and from 10 to 12 employed about the Quarry--2 of the Blacksmiths are required to sharpen the tools for the hammerers and ledgemen and the other have been busy in making tools & putting the different apparatus in order, repairing and making Jacks etc.--Our tools and Apparatus for Quarrying are in good order except a deficiency in Block and Ropes for hoisting. Such as we have had the past Season, are nearly worn out, and were principally Borrowed and always too weak for our purpose.--We shall consequently want 4 new double Blocks for the Quarry, of a size fit for a Rope 1 1/2 inch diameter and two ropes to fit the same, besides some single Blocks to use....We shall also want two double Blocks, and some single ones,...for an Apparatus to do the loading at hammerers Shed.--As these blocks wanted are of an extra size, they are not kept at the Blockmakers, and consequently must be made expressly for the work--....

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47. Willard, Obelisk on Bunker's Hill, p. 24.

48. Gridley Bryant, "Granite Railway Company Agent's Book," August 9, 1830. MSS., Quincy Historical Society.

If a larger number of hammerers are to be employed the necessary preparation should be made before the opening of Spring--Each hammerer requires a set of tools consisting of 3 Pick hammers, 1 Hand hammer--1 Set 10 Points, 8 Chissels, and a square, with the number stamped on the tools, in order that they may be known.--They should be arranged in a convenient box, with lock and key. Each hammerer will want six feet in length of Shed Room, and there should be a faced hammer to every 4 of the workmen...[49]

At the Wigwam Quarry there was a Blacksmith and forge for every ten to twelve hammerers. Each forge required a pair of bellows, an anvil, a pair of tongs and two tubs, one for water, the other for brine.[50]

EXTENSION OF DRY DOCK 1

When the Dry Dock 1 at Charlestown was designed and constructed it was large enough to hold the largest ship of the line owned by the U.S. Navy. By mid-century, however, larger ships were an important part of the Naval fleet and plans were made to extend the dock to accommodate them. In 1857 Dry Dock 1 was extended sixty-five feet at the head.[51] This was done by removing the masonry at that end of the dock sixty-five feet inland and filling in the resulting voids in the side walls with new masonry.

The granite used in extending Dry Dock 1 was primarily Cape Ann or Rockport granite rather than Quincy granite. The coping stones, however, were Quincy granite.[52] There are subtle differences in the color and character of the two stones. The most noticable difference between the new and old work, however, is the size of the stones used. By 1855 quarrying techniques allowed much larger

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49. Solomon Willard, "Letter Book," June 31, 1836, MSS., Massachusetts Historical Society.

50. Ibid.

51. Preble, "History of the "Boston Navy Yard," p. 574.

52. Ibid.

blocks to be taken from the quarry. As a result, the granite used in the 1857 extension of Dry Dock 1 are equal in depth to two courses of the earlier work. The new work has courses thirty-four to thirty-five inches while the earlier courses were seventeen to eighteen inches deep. The difference in the length of the stones ranges up to thirteen feet for the new work while the old stones are generally between four and six feet.

Rockport granite is of two sorts. Both are hornblende granites. The first and most abundant is known as "gray granite." It has a medium shade of gray spotted with black. The second variety is known as "green granite" and has a dark olive-gray color spotted with black. After quarrying this stone takes on a greenish color which becomes muted with exposure.[53]

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53. Dale, Commercial Granites, pp. 123-24.

APPENDICES

APPENDIX A

Advertisements for materials for the construction of the Dry Dock.

DRY DOCK.

CHARLESTOWN NAVY YARD.

PROPOSALS will be received, by the subscriber, until the 20th of October next, for furnishing and delivering for the *Dry Dock*, in the Navy Yard at Charlestown, the following quantity of PINE TIMBER and PLANK, viz:—

200 tons of sound, straight, square edged *White Pine Timber*, to be free from large knots, 13 inches square, and in lengths of 28, 31, 37 and 40 feet—one quarter part each.

400 tons of sound, straight, square edged *White Pine Timber*, free from large knots, 13 by 17 inches square, and in lengths of 25, 35, 40 and 45 feet—one quarter part of each.

280,000 feet, board measure, of *White Pine Plank*, 3 inches thick, sound, square edged, and free from large knots, to be not less than 25 feet long, and to average 33 feet in length.

60,000 feet, board measure, of sound, square edged *hard or yellow Pine Plank*, 4 inches thick, for sheet piling, to be free from large knots; one third part of the quantity to be 10, one third 15, and one third 20 feet long, not less than 12 inches wide, and each plank to be of equal width at both ends.

A part of said Timber and Plank to be delivered as early next Spring as possible, and all on or before the 1st day of July next. The whole will be surveyed and inspected by the Inspector of the Navy Yard, at Charlestown; and bonds, with good and sufficient security, will be required for the faithful performance of the contracts.

Proposals for the whole or any part of the above lumber, accompanied by the names of the proposed bondsmen, sealed up, will be received on or before the 20th day of October next, by the subscriber, at the *Dry Dock Office*, in the Navy Yard, at Charlestown.

L. BALDWIN, *Engineer.*

Navy Yard, Charlestown, September 3th, 1827. } eptO20

DRY DOCK,

CHARLESTOWN NAVY-YARD.

PROPOSALS will be received by the subscriber, until the 1st of November next, for furnishing and delivering GRANITE STONES, for about 20,000 cubic yards of Masonry for the Dry Dock.—About 5000 yards to be furnished so as to be hammered to the dimensions, and in the quantities respectively designated by letters, in the following schedule, in which the quantities, the height and depth of the blocks of stones are given.

A	22275	cubic feet,	2 feet	by	3:3
B	2145	do	1:6	"	3:3
C	17820	do.	2	"	2:9
D	17010	do.	1:9	"	3
E	8652	do.	1:6	"	2
F	3822	do.	1:6	"	4:3
G	18099	do.	1:2	"	2
H	3477	do.	1:1	"	3
I.	9075	do.	1:3	"	3
J	11220	do.	2	"	3
K	7560	do.	2	to	3 square
L	12600	do.	1:6	by	2:6
M	4222	do.	in 286 steps, to rise 8 inches, 1:2 wide, and 5:5 long		

The stones marked A B C D E and J will be hammered in the Yard, to patterns and nearly to the above dimensions, in lengths from 3 to 8 feet. The stones F, in lengths from 3 to 6 feet, may be delivered hammered ready for laying. Those marked H, for coping stones, and those for ashler work G L, may also be contracted for either rough or hammered, as well as the steps M. All the stones, except the ashler work, to be in blocks from 3 to 8 feet long, and the ashler stones to be hammered on the face, with good joints, bed and build, at least 1 foot wide, and in regular lines of headers and stretchers.

The remaining 15,000 cubic yards of masonry will consist of good rubie backing, in courses of 13 inches thickness and of suitable length and width. All the dimension stones above designated will be got out to pattern, to be paid for by the cubic yard as it will measure when hammered, and all rubie backing to be paid for as measured when laid, and it is wished that the proposals should be made accordingly. The coping, ashler work and steps, may be hammered and delivered ready for use, on such terms as may hereafter be agreed upon.

The delivery of the stones must commence next May, and be continued as they may be required, so that all shall be delivered in 1829. The whole of the dimension stones will be inspected and measured by the master mason, as they are delivered.

Good and sufficient security will be required of the Contractor for the faithful performance of his contract.

Proposals for the whole or any part of the above stones, accompanied by the names of the proposed bondsmen, sealed up, will be received on or before the 1st day of November next, by the subscriber, at the *Dry Dock Office*, in the Navy Yard, Charlestown, where those wishing to offer proposals, may see the plans, patterns, &c. and where further information may be obtained from ALEXANDER PARRIS, Esq. the Superintendent.

L. BALDWIN, Engineer.

NAVY-YARD, Sept. 28, 1827. ep2wcoptN

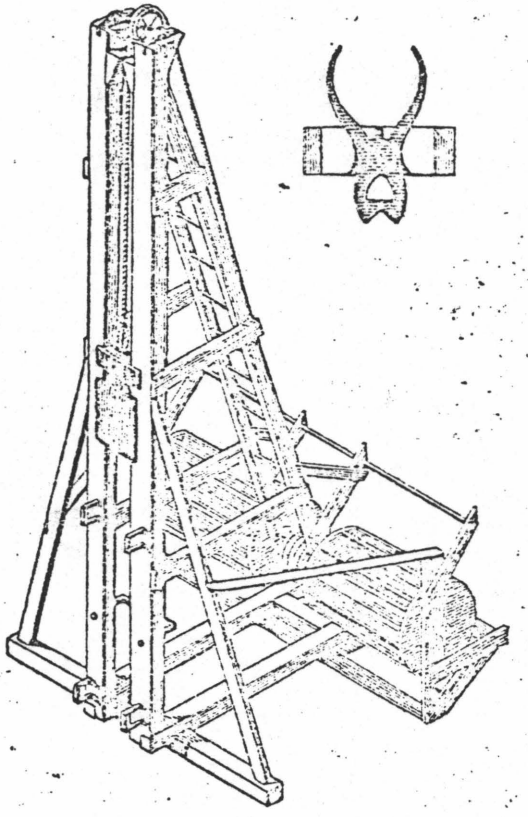
APPENDIX B

Article on Pile Driving Machine used in construction of Dry Dock 1.

Mechanic's Magazine and Journal of Internal Improvement, vol. 1, Boston, 1830, pp. 144-45.

COMMUNICATION.] [FOR THE MAGAZINE.

PILE DRIVING MACHINE.



Mr. Editor,—The London Mechanicks Magazine of January and February, 1830, contains a description, and a number of engravings, of various kinds of pile driving machines. Being unwilling to see our English brethren triumph over us, in all that relates to the arts and sciences, I have sent you an isometrical projection* of an improved pile engine. This is an application of the tread wheel instead of the crank. Something similar to it, was first used at the building of the Boston and Roxbury Mill Dam, about the year 1819, but has not from that time, till within three or four years since, again been brought into use. There has been four or five of these machines in operation at the Dry Dock, Charlestown Navy Yard, since the commencement of that important work; and I have frequently seen them on the new streets near Charles River bridge. It is found that eight men on the wheel, with one overseer, whose duty it is to keep the pile in a perpendicular direction during a few of the first blows of the ram, will do one third more work than the same number can on one of the best constructed machines with a crank; that is to say, those on the former, have arranged nearly 14 piles of 8 to 12 feet in length in a day, while those on the latter were not able to drive more than 9. The ram of the machine from which this drawing was taken, weighed about 2005 pounds. The nippers, or tongs, were constructed in a better manner than those described in the London Mechanicks Magazine. The arms, or parts which slide between the inclined planes, were nearly three times the distance of the lower ends from the fulcrum or centre of motion, while in the English ones they are very nearly equal. When the ram arrives at the top of the machine a vast deal of friction takes place; so much so, that the men are obliged to exert a great force to disengage it. It is clearly evident that in the first case, there being a greater lever power the pincers may be separated by a much smaller force than in the second. Most people have an aversion to the tread wheel, because it is employed in England and other countries as a mode of punishment, imagining its use to be to tire and weary the criminals; but this is not the case in regard to this application of it, as the men have a chance of resting a few seconds every time the ram drops, and I have heard workmen who have been accustomed to this machine say they decidedly preferred it to any other.

The parts of this engine may be so easily understood from the drawing that they will need no particular description.

E.

* Some account of this useful method of drawing, invented by Professor Farish, may be found in Dr. Gregory's Mathematicks for Practical Men.

APPENDIX C

List of expenditures for original construction of Dry Dock 1, Charlestown Navy Yard, 1833.

Baldwin Collection, vol. 69, Baker Library, Harvard University.

The following abstract of the Schedules presents a convenient exhibit of the total expense of the Dock.

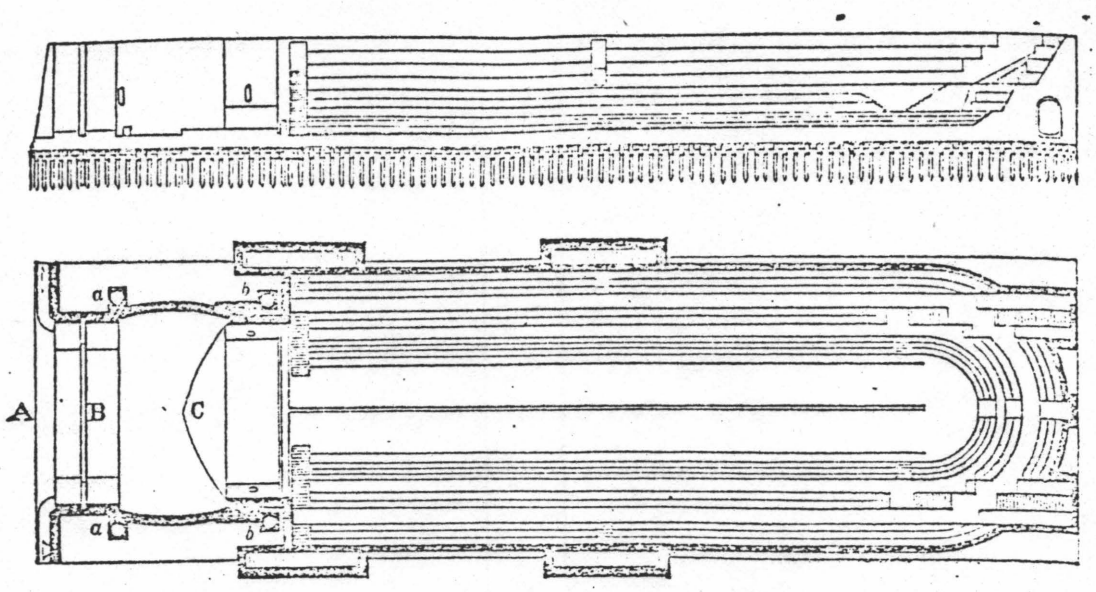
Abstract of expenditure on the different branches of the work for the year ending Oct. 31. 1833 & also from the commencement to the completion of the work.

No.	For the last Year.			From the Commencement.		
	Materials	Labour	Total.	Materials.	Labour	Total.
1. Office	$212 43	- - -	$212 43	$1784 55	$266 19½	$2050 72½
2 Tools	362 82		368 82	2537 35	1861 09½	4398 94½
3 Iron & Steel	36 91	634 69	671 60	11305 48	2262 99	33925 47
4 Sawing Machines				1918 20	1188 74	3106 94
5 Scows, boats &c				1355 34½	687 09½	2042 68½
6 Coffer Dams				4399 18	7103 90½	11503 08½
7 Pier Wharves	135 82	2129 74	2265 56	7286 01½	6871 83	14157 84½
8 Spruce & Pine timber				1967 31½		1967 31½
9 Blacksmiths Shop	164 25		164 25	8181 58	312 21½	8493 79½
10 Miscellanies	3857 15	1580 22	5437 37	11594 54	19015 29½	30609 84½
11 Dry Dam Wall				5625 37	102 81	5728 18
12 Filling Coffer Dam				2573 28	537 34	3110 62
13 Surveys & plans of Navy Yards				1132 18	1764 37	2896 55
14 Foundation of Dock				18686 16	22451 40	41137 56
15 Draining				11654 44	9537 27	21191 71
16 Excavation				2259 86	29795 50	32055 45
17 Masonry of Dock	1464 72	835 80	2300 52	116953 52	123502 66	240456 18
18 Grate Steam Engine	1190 28	1933 19	3123 47	12015 12	2846 76	14861 88
19 Superintendence	2095 46	3048 82	5144 28	14955 80	30464 37	45420 17
20 Banking up behind walls &c	3300 68		3300 68	7467 31	13090 77	20558 08
21 Turning Gates	1746 74	1927 90	3674 64	16806 66	9509 95	26316 61
22 Grate Pumps	212 92		212 92	28114 55		28114 55
23 Removing Coffer Dams &c	2979 49	4794 48	7773 97	4642 50	9623 59	14266 09
24 Steam Engine House, wells &c	454 75	376 24	830 99	14767 39	19593 83	34361 22
25 Hauling Gate	16096 23	11537 94	27634 17	19684 85	12288 06	31972 91
26 Wicketo Gates	313 16		313 16	2308 06	129 30	2437 36
Total	$34623 79	28799 04	63422 83	331922 34½	345167 43½	677089 78½

APPENDIX D

Article on the Dry Dock at Charlestown, 1835

American Magazine of Useful & Entertaining Knowldege, vol. 1, Boston, 1835, pp. 298-300.



DRY DOCK AT CHARLESTOWN.*

REFERENCES.—A, is the entrance to the dock; B, is the floating gate, and C the turning gates. *aa*, shows the situation of the capstans for opening the turning gates, and *bb*, the situation of the capstans for shutting them.

An account of the dry dock in Charlestown, belonging to the United States, and recently constructed for the ships of the Navy, it is thought, will be acceptable to many of our readers.

Surveys for a site for a dry dock were ordered by Congress, May, 1826, and were soon after made by Colonel L. Baldwin, of Masssachusetts; and in 1827, it was concluded to construct two, for the use and benefit of the Navy of the United States; one north and the other south of the Potomac. After the necessary preparations were made,† a *copper dam* was first built, in front of the old battery, in the Navy Yard at Charlestown, extending beyond the low-water mark, consisting of two rows of sheet piles, from eight to thirteen feet apart, the spaces filled with earth to resist the pressure of the tide during the building of the dock. Six hundred feet of quay wall, with an embankment, was also built, the north-east side of the site for the dock.

The excavation was begun in May, 1828, and sheet piles, plank and other timber prepared for the foundation of the dock; and stone cutters employed to get the stone in readiness, for the superstructure. In May, 1829, the first stone was laid, while the other necessary work was going on. The foundation is composed of piles three feet apart, driven about eight feet deep, on which rest timbers one foot square; the space between being filled with broken stone, which are also rammed under the timbers to the depth of about eight inches. An additional row of piles is driven along the axis of the dock and under the keel, the distance of two hundred feet. On the timbers is laid a course of three inch plank, well secured with spikes and treenails and another course of timbers, sixteen inches deep directly over the piles; and the space between the timbers filled with brick, laid in water-proof cement. On this is another course of plank like the first, and secured in like manner; making a level floor, on which the stone-work of the dock rests. Round the whole exterior boundary of this floor runs a line of sheet piling, to prevent the passage of water under the floor, and to stop its admission between the two courses of floor plank. Under the gate and crossing the dock are similar lines of sheet piles connected with those on the sides, and well secured to additional cross sills and timbers.

The stone work commences at the depth of thirty two feet below ordinary high water, rising four feet above it, and covering an area of one hundred feet wide, three hundred and forty-one feet long, as given below; viz:

	ft.	in.
From the outside of the wing-walls to the beginning of water-walls of entrance	5	9
Thence to beginning of recesses for turning gates,	21	3
To point of mitre sill,	21	3
To line of heel posts of turning gates,	14	0
To gutter, (the bottom and side walls being curved,)	18	0
To face of return walls at foot of chamber of dock,	4	0
To centre of semi-circular head of dock,	206	0
To head of dock within the coping, being the radius of the head,	43	0
To extreme end of backing at head,	7	3
Total,	340	11

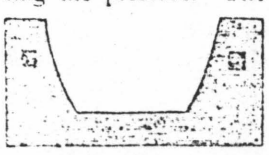
The interior structure of the dock: the stone floor is thirty feet wide between the first *altars* and at the lower end, at the discharging gutter, the whole masonry is four feet deep on the floor. From this end, the ascent to the centre of the semi-circular head is one foot three inches in a distance of two hundred and six feet, and in the middle of the floor, and under the blocks on which the keel of the vessel is to rest, runs a gutter, one foot wide, for leading the water to the discharging gutter. From the bottom of the dock, on each side, rise *altars*

* Wet docks have long been used; but dry docks are quite a recent invention, and are designed as a receptacle where a ship may be inspected, and all its defects detected and easily repaired. The dry dock must be perfectly water-tight, and the greatest skill and care are requisite in its construction. The expense is necessarily very great; and therefore, for small vessels the marine railway is more in use for repairs.

† Alexander Parris had the superintendence of the work, and was assisted by Edward Battles, a very ingenious mechanic.

from one to four feet high, and from two to four wide, and ascend to the top of the dock, conforming nearly to the form of the sides of a vessel, (but leaving sufficient room for the workmen when repairing in dock) and running throughout the whole extent of the chamber, (except where interrupted by stairs and slips) giving a depth of thirty-two feet from the *coping* to the floor of the dock, and eighty-six feet interior width between the faces of the coping. The semi-circular head is formed with altars having rises and breadths corresponding to those on the sides. There are six flights of steps to descend into the chamber and five sets of slips at the head, for getting down timber or other materials. The discharging gutter at the foot of the chamber of the dock, is continued through the masonry of the return walls, on each side, in *arched culverts* two feet wide and five feet high; extending forty feet from the axis of the dock. Here the water will be discharged into *side* culverts, two feet six inches wide and four feet high, arched at top and bottom, extending about two hundred and fifty feet to a *reservoir*, arched at top and bottom, of seven feet width and eleven feet extreme height, and about eighty-five feet long. From this reservoir the water is conducted by a tunnel to the great wells whence it is pumped out and carried by a drain about four hundred feet long, to the sea.

The side walls and bottom of that part of the entrance between the foot of the chamber of the dock and the turning gate posts form an inverted arch. The turning gates, which are thirty feet ten inches high and about thirty-six feet wide each, are composed of twelve white oak ribs, two feet square, and carved into a radius of about seventy feet, tenanted into heel and mitre posts, planked and coppered. The heel post turns on a composition metal pivot, and two rollers are attached to the lower rib, one near the mitre post and one near the middle, and are made to traverse on cast iron tram plates let into the floor of the dock. The gates are opened and shut by means of chains attached to the mitre posts and connecting with capstans placed on the coping. From the heel posts to the end of the gate recesses, the walls have a horizontal curvature, conformable to that of the gates. The mitre wall, against which the gates shut, and the floor over which they swing, are horizontal; the former being one foot six inches higher than the latter, and thirty feet below the top of the dock. The side walls of that part of the entrance, beginning at five feet nine inches from the sea, and extending to the recesses of the gates, are partly curved. The floor between the feet of the interior faces of these side walls is horizontal, and is thirty feet below the top of the dock. In these side walls and bottom is cut a groove of two feet wide and fifteen inches deep, to receive the *floating gate*, to be used in case the turning gates should require repairs, or to relieve the strain on them by dividing the pressure. The floating gate is formed like a vessel, with the stem and stern similar. The frame work consists of twelve horizontal ribs, the six lower of which are of live oak, and the three middle of white oak and the upper of pine; the specific gravity of which regulates its position in the water; these ribs are planked and coppered. When it is required to use this gate, it is floated into the direction of the groove, so that the keel may enter it, and filled with water, which causes it to sink, and forms a barrier against the sea.



Along the backing masonry of the side walls of the entrance, are two *filling* culverts, one on each side, two feet six inches wide, and of the same height, and twelve feet below the top of the coping. They open from the tide water, in the exterior face of the wing wall, and extend eighty-four feet to square *well rooms*, constructed near the beginning of the discharging culverts.

All the faces of the interior masonry of the floor and altars, the faces of the entrance and wing walls, and bottom of the entrance, are of hammered stone work, laid in water-proof cement. The bottom courses of masonry over the whole floor, about one foot six inches in depth, as well as one foot six inches in thickness around the whole exterior backing of the dock and entrance, are also laid in cement. In all such parts of the masonry of the dock, where it has been deemed desirable, the courses of stone are so arranged as to form arches, to resist the upward pressure.

The whole stone work in the dock amounts to about five hundred thousand cubic feet. The stone was quarried at Quincy, and is furnished by contract. It was brought on the railway to the landing on Neponset river, and thence transported to the Navy Yard in steam tow-boats.

The reservoir and discharging culverts, before described, are designed to facilitate the docking of ships; the admission of water from the tide, either into the dock or reservoir, or from the dock to the latter, being commanded by *draw-gates* or *shutters*.

When a ship is to be docked, the filling culverts are closed, as well as the passage from the dock to the discharging culverts and reservoir, and the water is pumped from the latter. The ship is then admitted, and the ponderous gates closed. In this situation, the discharging gates are drawn, and the water allowed to flow into the discharging culverts and reservoir, and thus, in a few minutes, the water is lowered several inches in the dock to hasten the shoring, and produce an immediate pressure on the gates, so as effectually to prevent the admission of water, and fix them steadily. The reservoir and culverts contain above seventeen thousand cubic feet of water; the water in the dock, &c. supposed level with the top of the upper altar, or four feet below the coping, at one foot in depth, is a little more than twenty-one thousand feet: and of this quantity, a ship of the line admitted at full draught, would displace above nine thousand cubic feet; consequently, to reduce the water one foot when the ship is in dock, only twelve thousand feet need be admitted to the reservoir and culverts; and the dock water may be lowered about one foot five inches to fill them. A complete command of the level, at the moment when a ship, especially a large one, is about to touch the blocks and to require the placing of shores, seems very important; and this mode will give a more perfect control of the opera-

tion, for the first foot, than could be obtained by the best regulated pumps or machinery.

The water is afterwards to be pumped out by the steam engine near the head of the dock. As the water is lowered the ship is propped up by shores, and is then ready to undergo repairs, which can be conducted with great facility and security.

Some doubts having been entertained as to the operation and efficiency of Mr. Lester's pendulum steam engine, and of its power to move all the great pumps, the following statement of their effect may be satisfactory. The cylinder of the steam engine is sixteen inches diameter, with a piston of forty-six inches stroke. The lower end of the piston rod is connected with a double crank, having a main shaft extending in opposite directions, and at the extreme end of each is a pinion of seventeen teeth. These two shafts are moveable, independent of the machinery which moves the pumps. Parallel with each main shaft are two other wrought-iron shafts, lying on a strong cast iron frame over the wells. These four shafts, called the pump shafts, have each a wheel of sixty-eight teeth at the outer end, geared and ungeared at pleasure into the pinion, with a crank pin, and a corresponding crank at the opposite end of the shaft, with a radius of eighteen inches. By the crank-pin and crank, each pump-shaft moves two lift pumps of two feet six inches diameter, making eight pumps in the whole. Besides these, the same shafts have each two chain pumps, the chambers of which are thirteen and a half inches diameter, and the diameter of the sprocket wheels is three feet eight inches. The whole pumps are therefore—eight lift pumps, with chambers thirty inches in diameter and three feet lift; eight chain pumps with chambers thirteen and a half inches in diameter and sprocket wheels forty-four inches in diameter. From the chamber of the dock the water is conducted through culverts built in the masonry to a well outside the masonry, and from the last it is conducted through a tunnel sixty-five feet long to the two great draining wells in which are placed the pumps. The tunnel is elliptical, with the longest diameter four feet perpendicular, and the short diameter two and a half feet, and is made of three courses of brick laid in water cement. The two great wells are fourteen and a half feet diameter, made of brick laid in cement, having the bottom concave like a reversed dome, with a curvature of two feet, the lowest point of which is thirty-seven feet below the coping, or five feet below the lowest part of the dock floor. The centres, or perpendicular axes of the wells are sixteen feet apart, and have a partition between them two feet thick in the thinnest part, except at the bottom, where an opening four feet high and two feet wide is left for an easy communication of the water between them.

At the depth of seven feet seven and a half inches below the coping is the floor of the cistern, built over the wells, into which the water is discharged from all the pumps, and from which it flows to the sea by a drain two feet six inches wide, and three feet high, having two valves or stop gates. When the pumps are in motion during high tide, the pumping is continued till the water rises in the cistern a little above the level of the tide, when it escapes by the drain. The top of the lift pump rises two or three inches above the floor of the cistern, and the top of the chain pumps five feet nine and a half inches above it.

On Friday, the 7th Sept. 1832, the pumping was commenced, and continued under the following circumstances. The water stood in the dock at a level ten feet below the coping, or six feet below ordinary high tide. At 10 o'clock, the whole sixteen pumps were set in motion, and continued an hour, the main shaft making from twenty-eight to thirty revolutions a minute. During this hour the water was lowered three feet, and from the measured surface of the water in the dock and space within the cofferdam, there were discharged about 85,000 cubic feet, equal to 637,500 galls. or 10,160 hhds. By calculating the effect of the pumps from the data before given, the result will be as follows.

A pump two feet six inches diameter, with a lift of three feet, delivers 14.72 cubic feet at a stroke, and when the Engine makes twenty-eight vibrations or revolutions a minute, which is assumed in the present instance, the pump makes seven strokes, and there being eight pumps, the effect for an hour is=7×8×14.72×60=49459 cubic feet, the main shaft making four revolutions to one of the pump shafts.

A chain pump thirteen and a half inches diameter, with a sprocket wheel of 3.67 feet diameter, gives 11.52 cubic feet per revolution; the effect is then=11.52×7×8×60=38707 cubic feet, and 49459×38707=88166 feet an hour for all the pumps, when the engine makes twenty-eight revolutions a minute. The average height to which the water was raised was six and a half feet, and by the eight chain pumps, nine feet eight inches.

The difference 3166 feet between the measured and calculated effect of the pumps as given above, arises principally from the space occupied by the chains and saucers of the chain pumps and the space occupied by the valves of the lift pumps, which were not deducted from the calculation.

During the second hour from eleven to twelve o'clock, four chain pumps were thrown off, and the engine made on an average about thirty-one revolutions a minute. The water was lowered three feet. The average lift of pumps nine and a half feet, and by the chain pumps twelve feet, eight inches. In the third hour all the chain pumps were thrown off and the water lowered two feet two inches, making in the three hours eight feet two inches. The Engine might have been driven forty instead of twenty-eight revolutions in the first hour if it had been wished. On Saturday the whole dock was drained.

The Engine and pumps completely perform all that was anticipated and nothing farther can be desired.

An Engine and pumps on the same plan have been constructed and put up for the Dry Dock at the Norfolk Navy Yard, but the engine is of nearly double the power. The piston is twenty inches diameter, and the stroke forty-eight inches, with five boilers. The pumps, which are of the same dimensions of these, and the engine, were made by Messrs. Lazell, Perkins & Co., of Bridgewater, pursuant to contracts made by the Engineer of the Dock, and under the immediate direction of their Engineer, Mr. Lester.

APPENDIX E

The Baldwin Library

The Baldwin Library is a collection of engineering and related texts, pamphlets, and periodicals presently on deposit in the Institute Archives at M.I.T. In 1899 the library was given to the Woburn Public Library by Mrs. C.R. Griffith, daughter of George Rumford Baldwin. The library was given on the condition, "That, if at any time it became impossible to care for it properly there, it be transferred to M.I.T." This action was taken in 1913.[1]

The library was begun by Loammi Baldwin I and contains early and rare eighteenth century volumes. The inventory of the elder Baldwin's estate, dated February 10, 1808 lists some of the volumes separately by title.[2] It mentions the more important volumes including "Gibbs, Architecture" and "Pain's Architecture" referring to famous works by English architects James Gibbs and William Pain. The final entry in the inventory of the library reads simply "48 old books." It can be assumed that some of these volumes dealt with mathematics and science. Undoubtedly there were also some of the books on literature and the arts that would have been found in the study of any gentleman at the time. It is important to note that there are books mentioned in the inventory which are not presently among the books known as the Baldwin Collection. Undoubtedly the library suffered deletions on many occasions.

The elder Baldwin's books were probably given to Loammi II at the time of his father's death. Loammi II had travelled in Europe and had added to the family collections of texts. At the turn of the nineteenth century there were very few American technical books. Early engineers relied solely on practical

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1. Margaret P. Hazen, "The Baldwins of Woburn, A Century of Engineering Achievement" Typescript. Institute Archives, M.I.T., Cambridge, Massachusetts. Hereafter cited as Hazen, "Baldwin Collection."

2. Inventory of estate of Loammi Baldwin, February 10, 1808. Baldwin MSS. Baker Library, Harvard University.

experience and books published abroad for their education. The younger Baldwin added numerous volumes to his father's library during the twenty-five years that he practiced engineering. This is evidenced by the fact that, at the time of his death in 1838 an inventory of Loammi II's library listed individually 264 French texts as well as 358 books in English. The twenty-four page inventory also listed "Pocket Maps," "Magazines, Reviews etc." and "Plans, Charts, etc." With the inventories of the two Loammi Baldwins in hand it is unnecessary to do much guessing in trying to determine which volumes were added to the family library by which of the Baldwin engineers. Later nineteenth century additions to the library and those concerning early railroads were probably purchased by James Fowle Baldwin (1782-1862) and George Rumford Baldwin (1798-1888).

The Baldwin collection today consists of the more than 2,000 volumes that survived a late nineteenth century fire. These volumes indicate the wide range interests held by the Baldwins. It is especially indicative of the interests of Loammi II who contributed a major portion of the volumes to the library. Canal building, navigation and steam engineering are well represented as are books on European public works and military engineering, an area in which the French excelled. [2] There are many examples of technical and general dictionaries and, to the author's delight, several volumes to assist oneself in learning French. A researcher not fluent in the language might use these period learning aids in using the French volumes!

There are several gaps in the Baldwin collection as it exists today. There are none of the large encyclopedias popular in the nineteenth century. The arts and literature are poorly represented. The important architectural volumes like Gibbs and Pain are missing from the collection at M.I.T. Any folios of drawings

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2. Hazen, "Baldwin Collection," p. 4.

mentioned in the inventories have also been removed from the library. The gaps in the collection can be explained in several ways. Unfortunately, speculation will never provide a definite answer as to why the volumes are missing from the Baldwin collection.

It is possible that the books on the arts were destroyed in the fire in 1898.[4] It is also possible that, at some point, certain volumes from the collection were sold or added to another family library. Certainly, architectural texts and pattern books had more market value than outdated, but not yet historic, treatises on math or engineering.

Study of the inventories of the libraries of the two Loammi Baldwins allows one to fill in many of the gaps in the existing collection. The interests of the Baldwins did include art, architecture, and literature as one would expect. In its present form, although missing some volumes, the Baldwin collection is undoubtedly one of the finest sources of information on the history of civil engineering in America in existance. It provides a unique opportunity for the study of the Baldwin projects and of the state of civil engineering as a profession in the United States during the late eighteenth and early nineteenth centuries.

There are several manuscript volumes in the Baldwin Collection. As stated earlier the bulk of the Baldwin papers are held by the Baker Library at Harvard. Sizable collections of Baldwin manuscripts are also found in Houghton Library at Harvard, the Essex Institute in Salem, Massachusetts, the Massachusetts Historical Society, and in the William L. Clements Library at the University of Michigan. The only extensive collection of Baldwin drawings, many of which are uncatalogued, is also on deposit at the Clements Library.

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4. Article from Woburn News February 4, 1898 in Correspondance file in Baldwin Collection. Institute Archives, M.I.T. Cambridge, Massachusetts.

APPENDIX F

Third Committee's Report on the Obelisk for the Bunker Hill Monument, July 1, 1825, as published in The History of the Bunker Hill Monument Association by George Washington Warren, Boston, 1877.

To the Directors of the Bunker Hill Monument Association.

The Committee appointed at a meeting of the Directors of the Bunker Hill Monument Association, on the seventh day of June, 1825, "to report a design of an obelisk or pyramidal structure, and to consider and report on the subject generally," beg leave to report: —

That they have carefully examined and considered the subject submitted to them by the above vote of the Board, and that they are unanimously of opinion that the most suitable monument to be erected, pursuant to the design of the Association, is an obelisk, or frustum of a quadrangular pyramid, the base of which shall be a square of thirty feet on each side, to rise two hundred and twenty feet from the platform or ground on which it is to be erected; to be surmounted with an apex having its upper angle ninety degrees, and to be fifteen feet square at the top, agreeably to the plans and section herewith presented.

That the position of the building shall be such that its four faces shall be respectively opposite the four cardinal points of the compass, and the north and south faces shall intersect, at right angles, the plane of the meridian passing through the axis of the monument.

That the foundation shall be laid twelve feet deep, or at such a depth as to give, upon careful examination of the ground, a stable and certain support to the fabric; and, upon the supposition that twelve feet is a sufficient depth for this purpose, the foundation shall commence on a square of fifty feet upon each side, and rise, by regular offsets or otherwise, to the proper height to receive the base of the obelisk, where it shall be at least thirty feet square. The stones composing the foundation to be at least two feet thick, and of the largest dimensions consistent with due economy and convenience in works of such magnitude. The stones to be all dressed or hammered in their bed and build, and to have no small irregular stones or rubble-work in the foundation.

That, in order to obtain a sufficient knowledge of the nature of the soil on which the foundation is to be placed, it is expedient to sink a well near the proposed site, either on the meridian before named, or on a line at right angles with it, opposite the centre of the east or west front. The Board will thus ascertain to what depth, and in what manner, a secure foundation will be attainable, and at the same time procure a convenient supply of water for all purposes required in the work.

That, previous to excavating for the foundation, the site should be carefully examined, to ascertain at what level, in relation to the surface of the hill about it, the platform shall be fixed; so that in forming the *terre-plein*, or a suitable and convenient area round the monument, an economical disposition of the earth shall be obtained, without incurring the expense of costly excavation or filling. Upon this point the Committee consider it very essential to preserve as high a level for the platform as the nature of the land will admit, consistent with that easy approach to, and promenade round, a public monument of such grandeur and importance.

That the obelisk shall be erected of the dimensions and proportions and in the manner represented in the plan and section of the drawing herewith presented. That is to say, there shall be formed, in the interior of the building, a hollow newel or drum, six feet in its interior diameter, and rising from the level of the platform to the top, to consist of a circular wall one foot and a half in thickness. Round this newel shall be constructed a winding staircase of hewn stone, four feet wide at bottom, with steps having rises not exceeding eight inches, and of such breadth of tread as to make an easy and commodious ascent. The interior face of the principal walls shall be circular and concentric with the newel, and the stairs shall be firmly imbedded in, and connected with, said walls at one end, and at the other they shall be secured in the circular wall, which forms the inner drum or newel. There shall be formed, at intervals, suitable landings, or places of repose, in the staircase, with narrow openings through the said circular wall of the newel, for the introduction of air and light. Through the principal walls of the obelisk shall be made openings to admit light, to be as high upon the outside as the thickness of one of the exterior stone courses, and half an inch or an inch wide. The interior of said openings to diverge sufficiently for the admission of light; or that said openings on the exterior shall be two or three inches wide, and filled, flush with the face of the building, with thick blocks of ground-glass, so as to preserve at a distance the appearance of uniformity in the color of the monument.

The principal outward walls of the structure shall consist of large, well-hammered stones, with the bed and build hammered or dressed sufficiently to give solidity to the whole mass, and no backing stones to be used which are not also well dressed, and of proper magnitude to suit the size of the exterior courses, which shall be from two to three feet in height, so as to present as few joints as possible to the weather.

That, in the execution of the work, it is expedient to make such contracts for supplying the materials, making the necessary excavations, dressing and hammering the stones, &c., as shall be found economical and expeditious; but that the erection of the obelisk, and all labor of laying the foundation, should be intrusted to the care and superintendence of an experienced stone-mason, of known industry and integrity, and the work to be performed by hired workmen under his direction.

That some skilful architect should be employed, in whom the public, as well as the Board, may justly have confidence, who shall make and prepare the detailed and working plans; and who shall see that the execution of the monument shall be, throughout, faithfully and substantially performed, agreeably to the plans and directions to be adopted and delivered by the Board, or a committee by them appointed for that purpose.

That, in order to carry on this most important work in a simple, expeditious, and efficient manner, it is expedient that a building committee, to consist of three members of the Board, should be appointed, to whom shall be delegated full and ample powers to enter into all contracts; employ an architect, superintending stone-mason, and other workmen and laborers; to furnish materials; and generally to do and perform all things in behalf of the Association which shall be necessary for the completion of the monument.

That, when the obelisk shall have been completed, and not before, there shall be formed round it a firm platform of broad, well-hammered stones, resting on foundation walls, and extending to the distance of twenty feet from each face of the building; having at the exterior boundary three steps of not more than eight inches rise each, running round the whole platform: the steps and platform to rest on firm and substantial stone walls, to be laid in such manner and to such depths as to resist all action of frost, or other ordinary cause of derangement.

That the construction of said platform, as well as every disposition or appropriation of the land belonging to the Association, round or adjoining the site of the monument, should be postponed until the completion of the obelisk, or until some urgent and unexpected exigency shall otherwise require.

That the estimate of the expense of the monument which is hereto annexed, and which the committee request may be considered part of their report, has been made upon consultation with one of the most experienced and skilful stone-masons that your Committee are acquainted with; and they present it, as nearly conformable to the foregoing description, and the most satisfactory as to its result, which can be expected for a work so entirely new and peculiar as the proposed monument.

In presenting this general description of a plan for the monument, together with a sketch of the scheme to be pursued in its erection, your Committee are aware that many details and minute descriptions of the work are wanting. They have considered that these might well be omitted in their report, as they would more properly be considered in preparing working plans for the execution of the edifice; and more especially as many slight deviations and modifications will necessarily be made in the workmanship, which require the attention and care of the architect. But they have thought enough has been given to enable the Board to decide upon its general merits. Several other propositions have been examined, which presented dimensions and proportions varying from those of the plan they herein recommend. One

scheme was to preserve the relative proportion of base and top, and to make the base a square of forty feet, and the top twenty feet. Another was to enlarge the base to forty or fifty feet, and give the top a proportionally smaller area, so as to present an outline more distinctly pyramidal. But your Committee having taken into consideration the funds already provided or probably attainable, as well as the practical compliance with the general wishes of the Board and the public, had no hesitation in adopting the plan recommended, as the one most likely to be finally and satisfactorily accomplished.

All which is respectfully submitted by

L. BALDWIN.
GEO. TICKNOR.
JACOB BIGELOW.
SAML. SWETT.
W. ALLSTON.

BOSTON, July 1, 1825.

Estimate of the Expenses of building an Obelisk 220 Feet high, on a Square Base of 30 Feet and 15 Feet, of Quincy Granite.

FOUNDATION.

Excavation for foundation, say 52 feet square and 12 deep $= \frac{52 \times 52 \times 12}{216} = 150$ squares at $2 per square	$300	
Foundation of masonry, say 50 feet square at bottom, 30 feet square at top, and 12 feet deep = 784 perches, which, including stones, hammering, mortar, laying, &c., at $10 per perch	7,840	
		$8,140

OBELISK.

Stones for walls of the obelisk 3,538 perches, of which 1,179 or $\frac{1}{3}$ for outside, at $5 per perch	$5,895	
and 2,349 or $\frac{2}{3}$ for interior, at $3 per perch . .	7,047	
Hammered face of obelisk 220 feet high, 3 feet base, and 15 at top, on each side $= \frac{30 \times 15}{2} \times 220 = 1950$ feet square on each exterior face, or $4{,}950 \times 4 =$ 19,800 square feet in the whole, at $0.50 . . .	9,900	
	22,832	

Amount brought forward	$22,832	$8,140
Average area of masonry 402 feet, 147 courses of 1½ foot each, gives for bed and build in square feet 402 × 127 × 2 = 118,188 feet. Add ½ for perpendicular joints 59,094 = 177,282; from this deduct ⅓ for outside . . . 29,547 = 147,735 feet. Hammering . = 147,735 feet, at $0.06 = $8,864. ,, for outside = 29,547 ,, .25 = 7,386.	16,250	
330 *steps*, 8 inches rise, average tread 1 foot, hammered rise and tread, say 2 feet, and 4 long in the draw = 4 × 2 × 330 = 2,640 square feet, at $0.50	1,320	
Stones for steps, 1.16 × .67 × 6 = 4.66 cubic feet in each, say 5 feet at $0.20 = $1 per step . . . $330 Laying do. at $1 each 330	660	
Laying 3.538 *perches* at $5 per perch, including scaffolds, rigging, &c.	17,690	
Extra hammering and laying circular staircase and hollow newel, say 20,000 feet, at $0.20	4,000	
Roman cement, say 100 casks, at $7 . . . . $700 Lime and sand, at $0.75 per perch 2,653	3,353	
		$66,115

Platform.

Platform, say 20 feet wide all round, and 3 steps 1 foot 2 inches tread each = 5.029 square feet of top surface. Rise of steps 8 inches, say 1 foot for top, &c. . . . = 1,176 square feet. 5,029 = 6,205 Hammered face = 6,205 square feet at $1.25, including stones, hammering, and laying	$7,756	
Foundation walls for platform and steps, say equal to ⅓ wall under whole 6 feet deep, 107 × 23.5 × 6 = 603 perches, at $5 . . . . . =	3,015	
Excavation for platform 24 feet wide all round the obelisk, and 6 feet deep, = 113 squares, at $1 .	113	
		10,914
Add for windows, iron clamps, railing to staircase, framework for window on top, door, &c. . . .		4,831
		$90,000
Add also for contingencies, superintendence, &c.		10,000
Total		$100,000

APPENDIX G

Advertisment for proposals for furnishing the granite for Dry Dock 1, Charlestown Navy Yard, Boston National Historic Park.

DRY DOCK, CHARLESTOWN NAVY YARD.—Proposals will be received by the subscriber, until the 1st of November next, for furnishing and delivering granite stones for about 20,000 cubic yards of masonry for the Dry Dock. About 5000 yards to be furnished so as to be hammered to the dimensions, and in the quantities respectively designated by letters, in the following schedule, in which the quantities, the height and depth, of the blocks of stones are given.

A.	22275	cubic feet.	2 feet by 3. 3.
B.	2115	do.	1. 6 " 3. 3.
C.	17820	do.	2. " 2. 9.
D.	17010	do.	1. 9. " 3.
E.	6552	do.	1. 9. " 2.
F.	3822	do.	1. 6. " 4. 3.
G.	13099	do.	1. 2. " 2.
H.	3477	do.	1. 1 " 3.
I.	9075	do.	1. 3 " 3.
J.	11220	do.	2. " 3.
K.	7560	do.	2. to 3 square
L.	12000	do.	1. 6 by 2. 6
M.	1222	do.	in 236 steps, to rise 8 inches, 1. 2 wide, and 5. 6 long.

The stones marked A B C D E and J will be hammered in the yard to patterns and nearly to the above dimensions, in lengths from 3 to 8 feet. The stones E, in lengths from 3 to 6 feet, may be delivered hammered ready for laying. Those marked H for coping stones, and those for Ashler work G. L. may also be contracted for either rough or hammered, as well as the steps M. All the stones, except the ashler work, to be in blocks from 3 to 8 feet long, and the ashler stones to be hammered on the face, with good joints, bed and build, at least 1 foot wide, and in regular lines of headers and stretchers.

The remaining 15,000 cubic yards of masonry will consist of good ruble backing, in courses of 18 inches thickness and of suitable length and width All the dimension stones above designated will be got out to pattern, to be paid for by the cubic yard as it will measure when hammered, and all ruble backing to be paid for as measured when laid, and it is wished that the proposals should be made accordingly. The coping, ashler work, and steps, may be hammered, and delivered ready for use, on such terms as may hereafter be agreed upon.

The delivery of the stones must commence next May, and be continued as they may be required, so that all shall be delivered in 1829. The whole of the dimension stones will be inspected and measured by the master mason, as they are delivered.—Good and sufficient security will be required of the contractor for the faithful performance of his contract.

Proposals for the whole or any part of the above stones, accompanied by the names of the proposed bondsmen, sealed up, will be received on or before the 1st day of November next, by the subscriber at the *Dry Dock Office*, in the Navy Yard, Charlestown, where those wishing to offer proposals, may see the plans, patterns, &c. and where further information may be obtained from ALEXANDER PARRIS, Esq. the superintendent.

L. BALDWIN, Engineer.

Navy Yard, Sept. 23, 1827 eplweoptN1

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Baldwin family business papers. Baker Library, Harvard Business School, Cambridge, Mass.

The Baldwin Collection in Baker Library is the most extensive collection of manuscripts relating to the construction of the Dry Dock at the Charlestown Navy Yard. Included in the numerous volumes of papers are invoices, notes and correspondence from the period of dock construction. The original contracts for materials for both the Charlestown and Norfolk docks are also in the collection.

Baldwin Collection. William L. Clements Library, University of Michigan, Ann Arbor, Michigan.

The Clements Library has in its map division over 600 drawings and related papers for projects that the members of the Baldwin family engineered. Many of these are construction drawings for the dry docks at Charlestown and Norfolk.

Baldwin Library. Institute Archives, Massachusetts Institute of Technology, Cambridge, Mass.

The Baldwin Library is presently on deposit in the Institute Archives at M.I.T. The library consists of over 2,000 volumes collected by Loammi Baldwin, Sr. and his sons, James, George, and Loammi, designer of the Dry Dock at Charlestown. The following manuscript volumes are in the collection:

New England Historical Geneological Society, Boston, Massachusetts.
"Payroll of workmen on the dry dock in Charlestown Navy Yard from June 16th, 1827 to Sept. 30, 1833." 2 vols.
"Register of Invoices," listing suppliers of stone to the Norfolk dock, dimensions of the stones and the dates of stone deliveries.
"Register of driving of Cofferdam piles in main part of Cofferdam." This volume contains "A Diary kept at the Dry Dock Office, Navy Yard Charlestown"; Nov. 1, 1827-May 16, 1828."

Papers of John Ripley Freeman. Institute Archives, Massachusetts Institute of Technology.

Quincy Historic Society, Quincy, Massachusetts.

Several Baldwin manuscripts relating to dry dock construction are presently contained in the papers of J.R. Freeman, civil engineer.

Photographs, drawings, and records relating to Dry Dock 1. Boston National Historical Park, National Park Service, Boston, Mass.

Material used is located in both the Archives and Maintenance Office at the Charlestown Navy Yard.

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ILLUSTRATIONS

ILLUSTRATION NO. 1

Dry Dock 1, Charlestown Navy Yard, Boston National Historical Park, 1979

Photograph taken by the author.

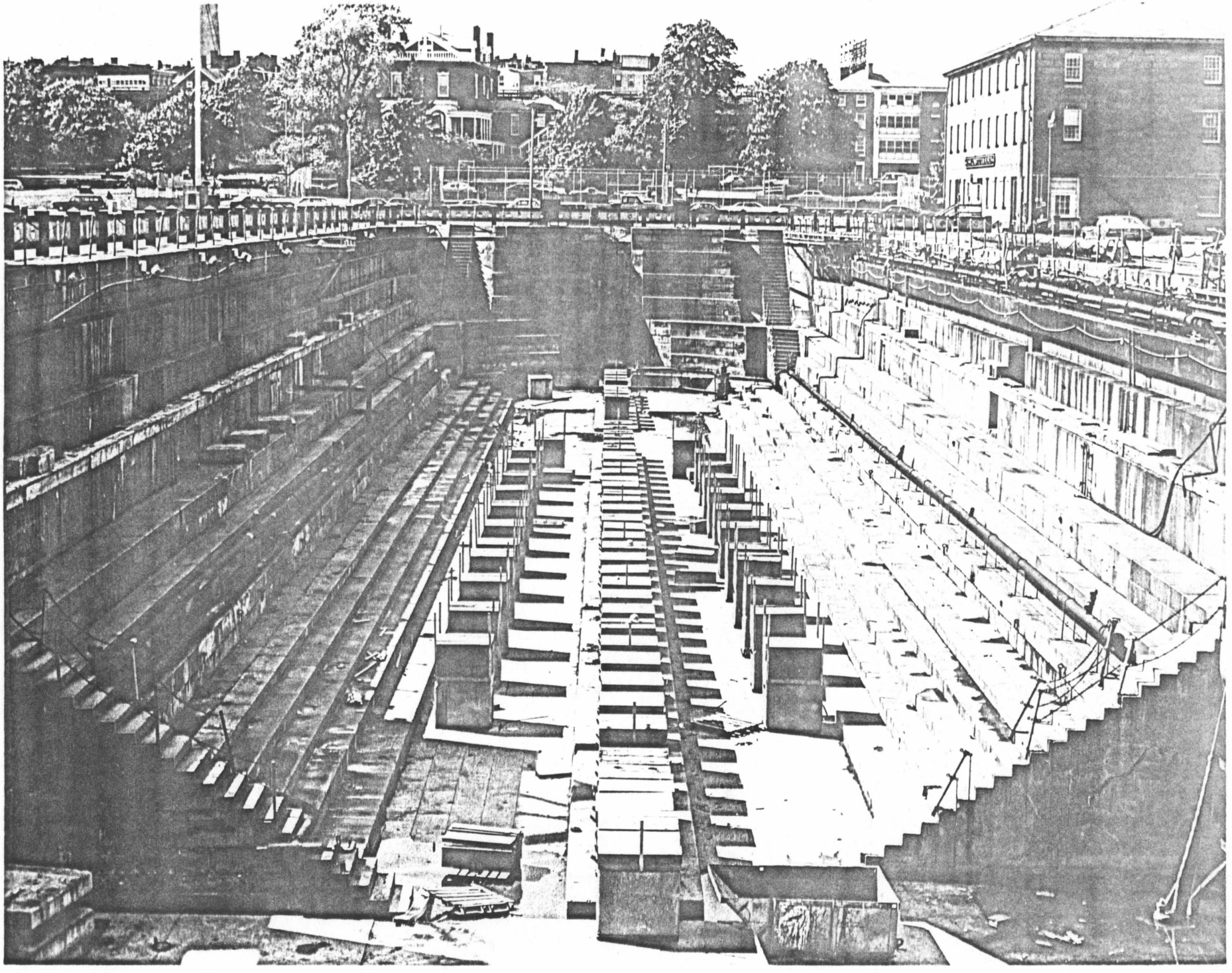


ILLUSTRATION NO. 2

"A Plan for the Navy Yard in Charlestown, State of Massachusetts."

This early 19th century plan of the Navy Yard is very close to a survey of the Yard done by Osgood Carlton in 1797. Early proposals for the dry dock construction included three docks measuring 250 feet by 70 feet rather than the one larger dock that was built between 1827 and 1833.

Photograph courtesy of Navy and Old Army Branch, National Archives, Washington, D.C.

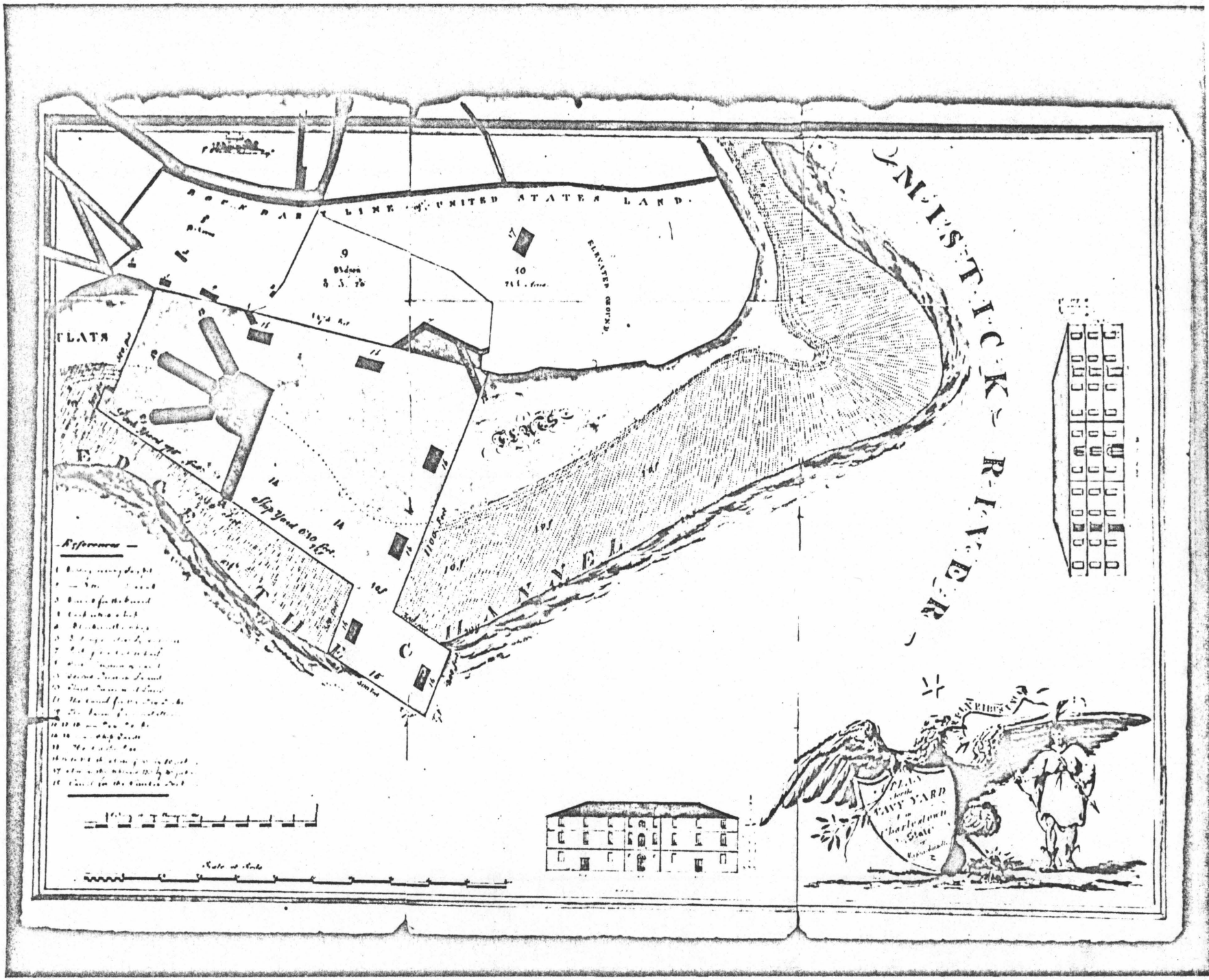

ROCK BAR
LINE of UNITED STATES LAND.
ELEVATED GROUND
FLATS
MYSTICK RIVER
Ship Yard 610 feet
Ship Yard 660 feet
Reference
NAVY YARD
Charlestown
State of

ILLUSTRATION NO. 3

"Sketch of the Position of the Dry Dock building at the Navy Yard, Charlestown, Ms. with the wharves and temporary buildings connected with it." Signed "Nov. 4, 1828. L. Baldwin." Baldwin collection.

Photograph courtesy of Baker Library, Harvard University.

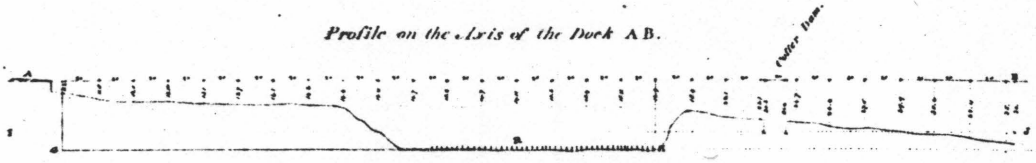
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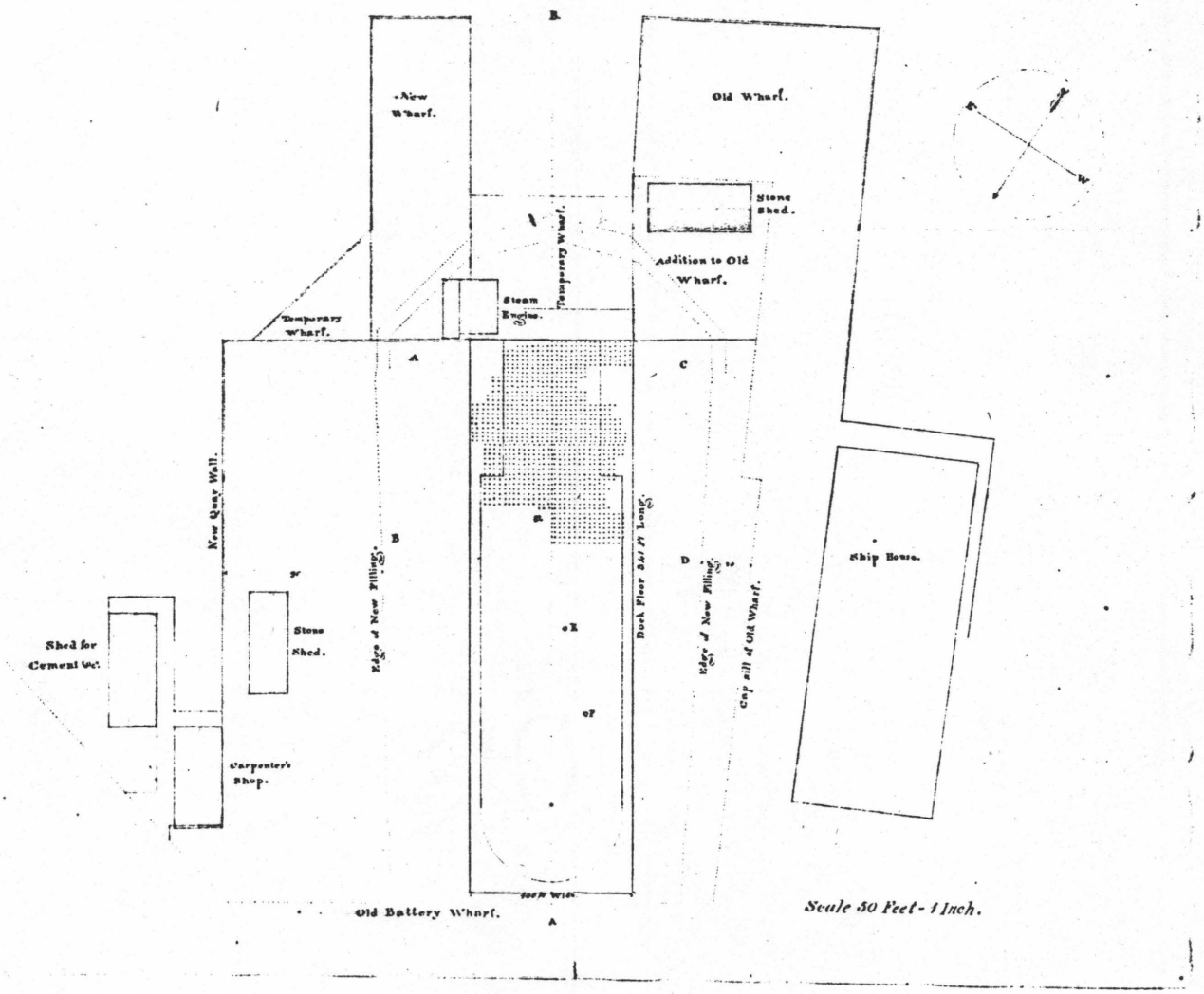
Sketch of the Position of the Dry Dock building at the Navy Yard, Charlestown, Ms. with the wharves & temporary buildings connected with it.

The red lines at GH, on the Profile, shew the Depth to be excavated, & the dotted line KL the level of the mitre sill of the turning gates, at 30 feet below the Level of the coping AB. RR. piles driven.

Nov. 4. 1820. L. Baldwin.

Profile on the Axis of the Dock AB.





Scale 50 Feet - 1 Inch.

ILLUSTRATION NO. 4

Original drawing for the construction of Dry Dock 1, Charlestown Navy Yard, Boston National Historical Park. Titled "Dry Dock Charlestown."

This section is probably one of the original working drawings for Dry Dock 1. It has the initials A.P.. Alexander Parris superintended the construction and would have approved the drawings.

The original foundation of the dock is well represented in this drawing. Foundation piles were driven first and timbers to carry a plank floor were laid over the heads of the piles. Spaces between the timbers were filled with rubble. A second layer of flooring timbers was placed on top of the first plank floor. On this level spaces were filled with brick masonry topped by a second layer of plank flooring. The stonework of the Dry Dock was laid upon this plank floor.

Photograph courtesy of the William L. Clements Library, University of Michigan, Ann Arbor, Michigan.

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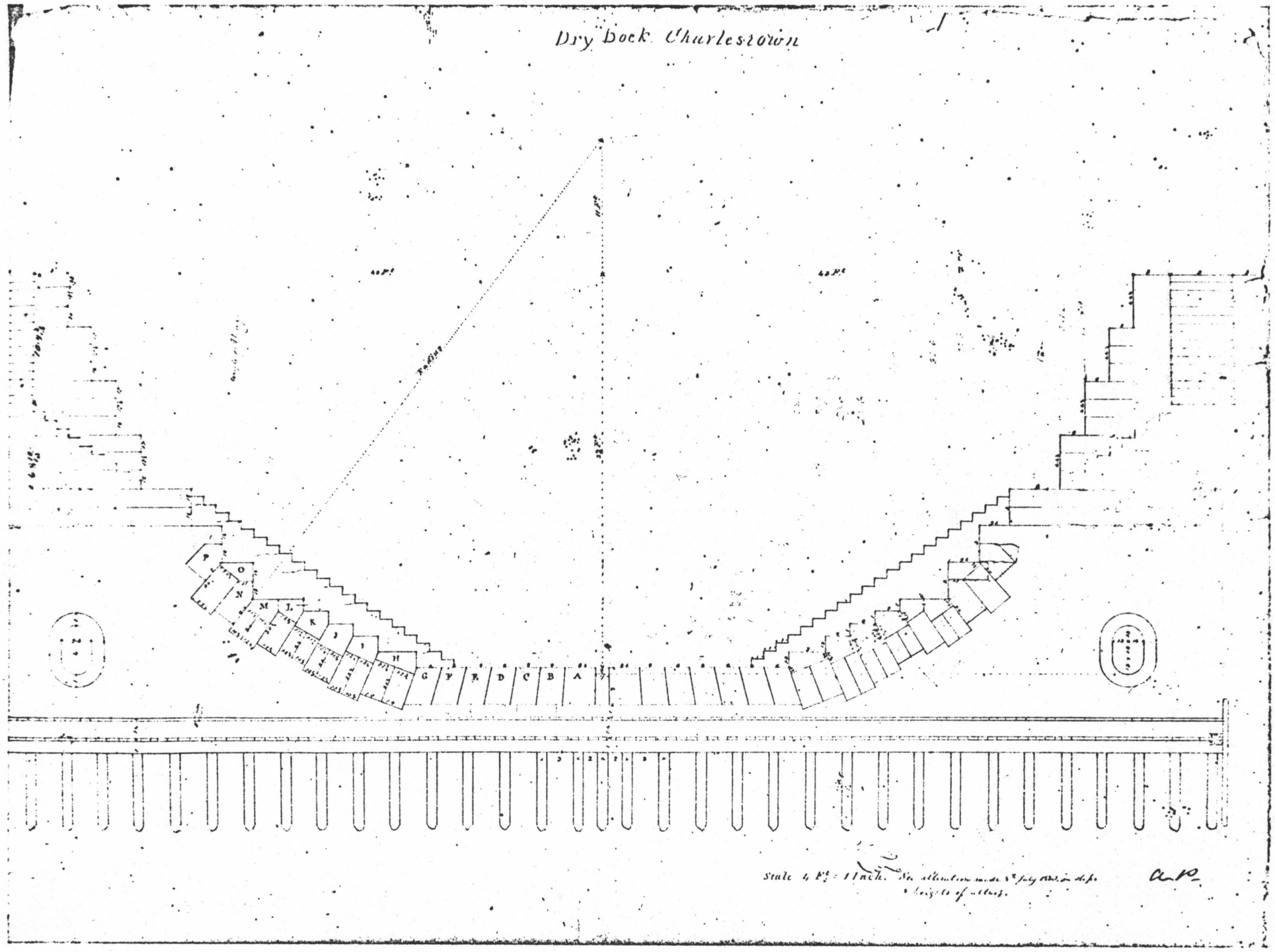

Dry Dock Charlestown
P
O
N
M
L
K
J
I
H
G
F
E
D
C
B
A
Scale 4 Ft = 1 Inch.

ILLUSTRATION NO. 5

"Wells & Pumps." This original drawing of the pumpwells for the Dry Dock was dated and initialled by Loammi Baldwin. The section shows four lift pumps. The Dry Dock originally had eight lift pumps and eight chain pumps.

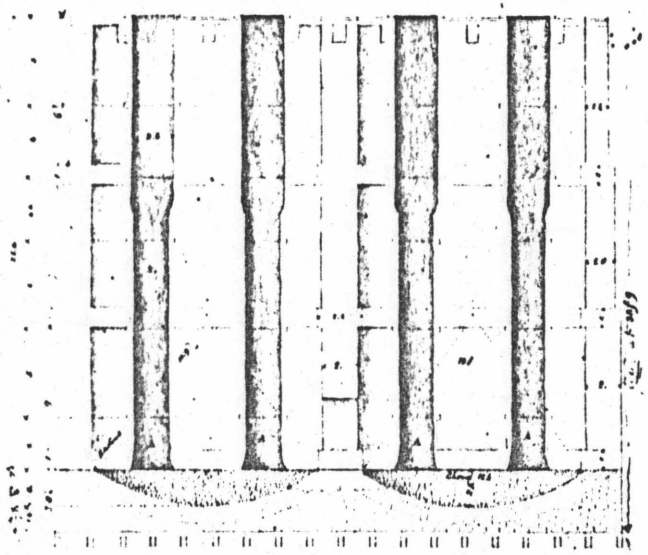
Photograph courtesy of the William L. Clements Library, University of Michigan, Ann Arbor.

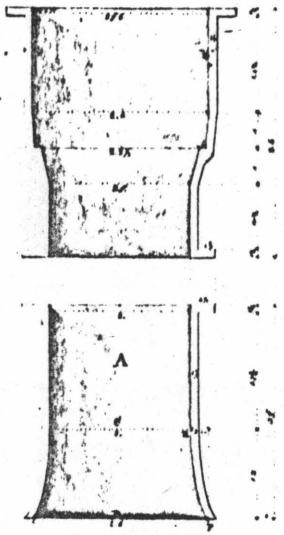
WELLS & PUMPS.

Top of Coping.

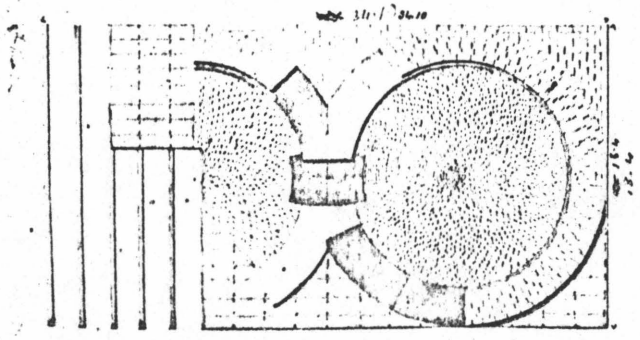
Ordinary High water.

Section of Wells & Lift pumps.





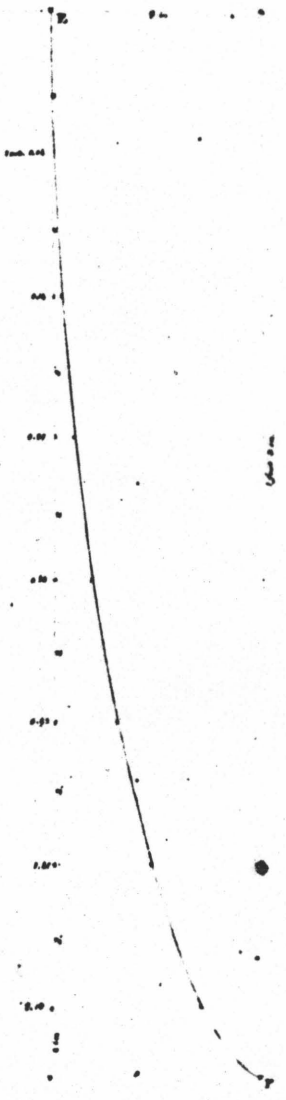
Plan of the Wells.



Scale 8 in. = 1 foot

Form of the Curve E.F of the lower joint A. Full size.

Interior Diameter at E = 2 feet.

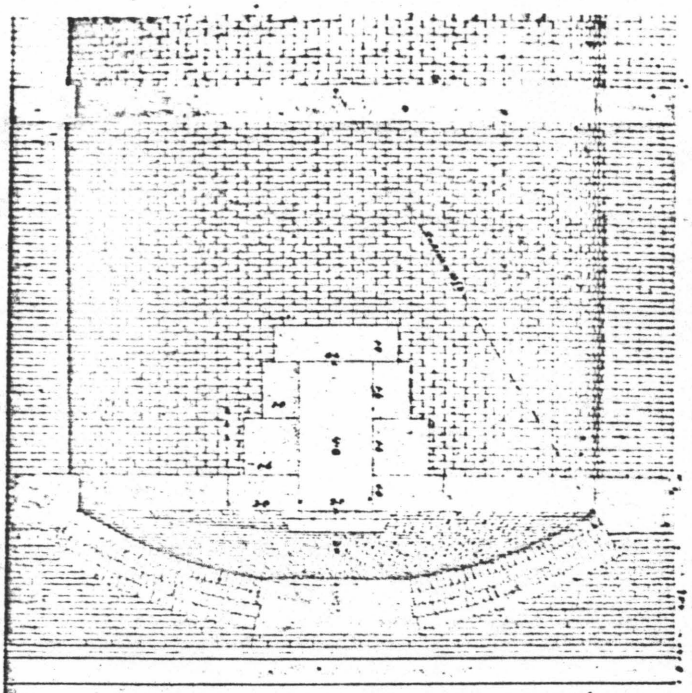


Interior Diameter at F = 2 f 6 in.

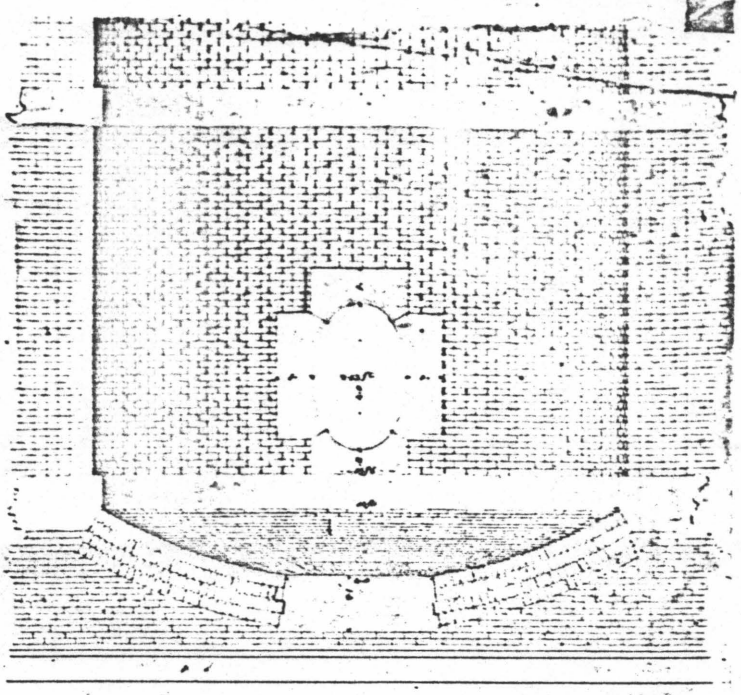
ILLUSTRATION NO. 6

"Plan of the Wells at Charlestown Dry Dock." This is one of the original drawings for the Dry Dock project. It was initialled by Benjamin F. Perham, a surveyor and draughtsman who worked on the Dry Dock. The wells were located underneath the Engine House. They contained eight lift pumps and eight chain pumps that were powered by Lester's great steam engine. The wells were built of brick and, although they are generally flooded, the wells are still accessible from the building above.

Photograph courtesy of the William L. Clements Library, University of Michigan, Ann Arbor.



Section on A.B.



Section at C.D.

Scale, 3 Feet to an Inch.

March, 1833.

No 3.

PLAN of the WELLS at CHARLESTOWN DRY DOCK.

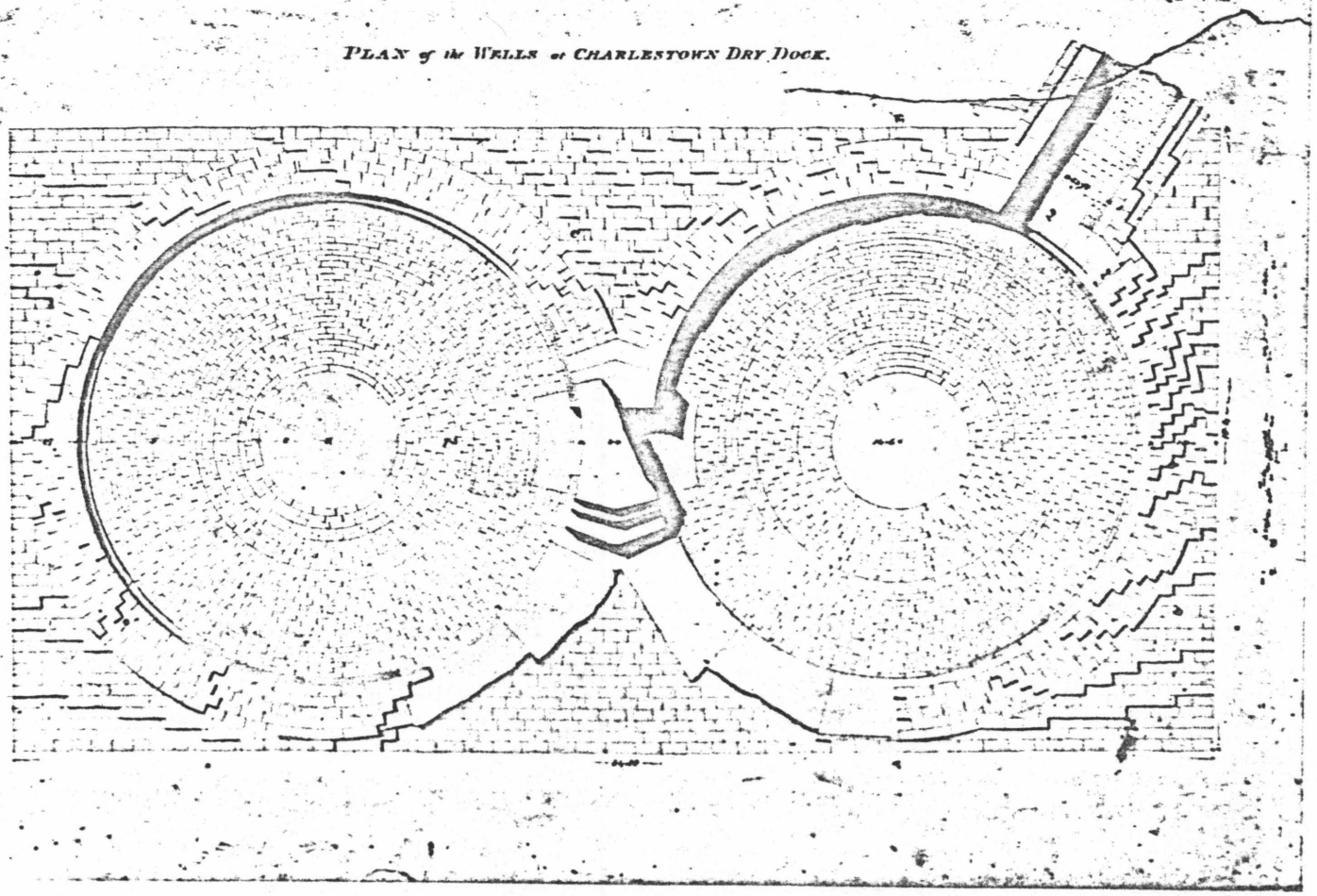
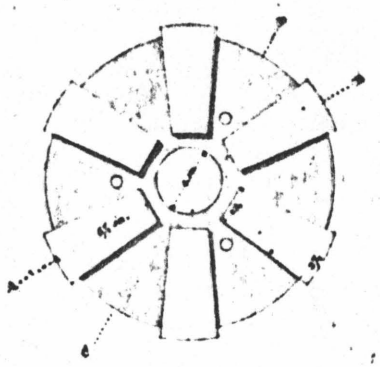
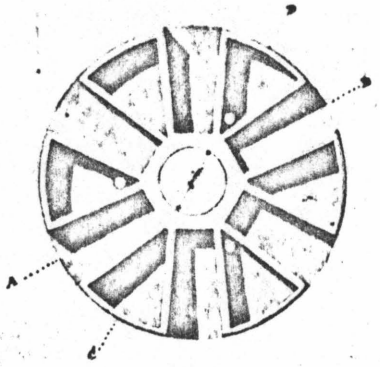


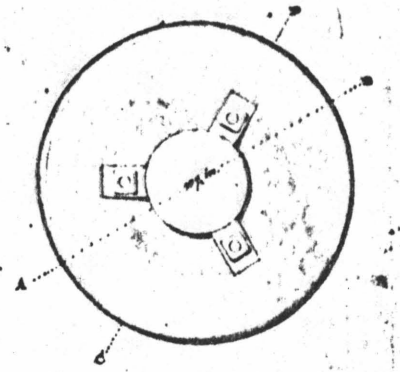
ILLUSTRATION NO. 7

Plans and sections of capstans used to power Dry Dock turning gates, initialled by Loammi Baldwin, April 1831. The capstan illustrated in this superb rendering was powered by a man or men who turned the mechanism with a winch inserted into the top section. Originally there were four such capstans adjacent to the Dry Dock. Two were used to open the turning gates. The other two were positioned so as to be used to close them.

Photograph courtesy of the William L. Clements Library, University of Michigan, Ann Arbor.

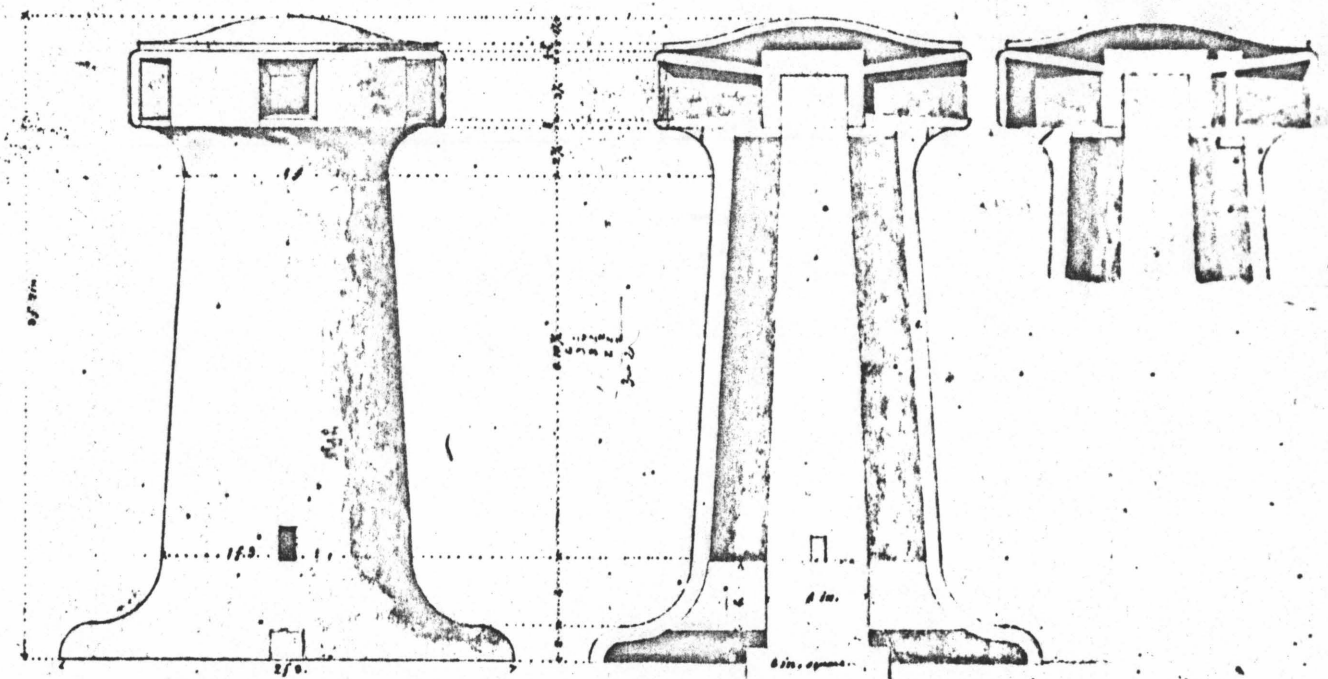


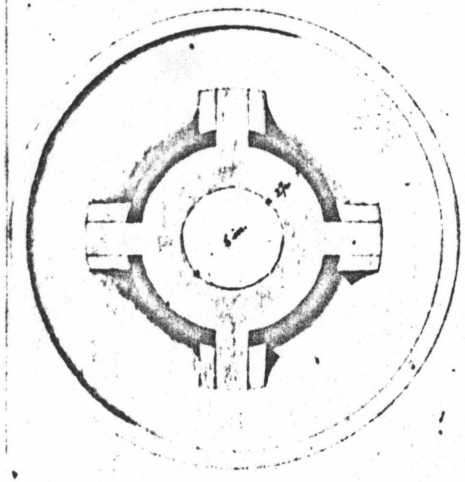




Section on A B.

Section on C D.





Scale 2 inches to 1 foot.

April 1831 J.P.

ILLUSTRATION NO. 8

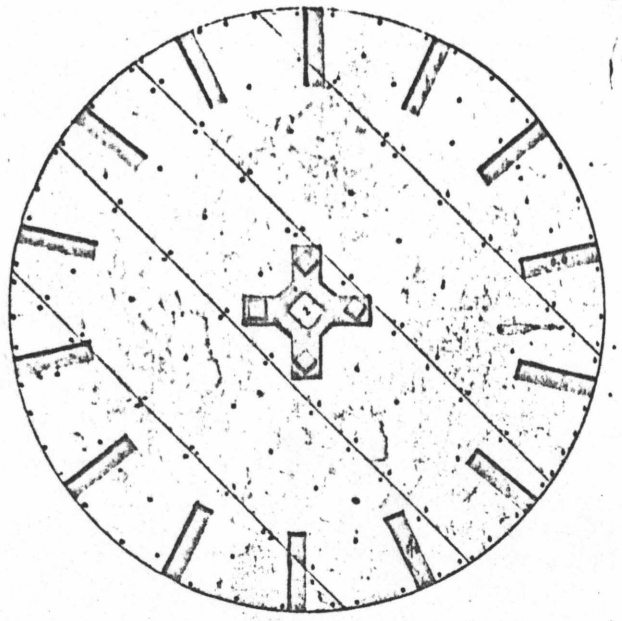
"Tread Wheel for a Driving Machine." This treadwheel was powered by eight men and was used to operate the pile driving machine used in the construction of the Dry Dock's foundation. Although this method was considered more efficient than powering a machine with a crank, it must have been a tedious process driving 4,027 foundation piles to support the Dry Dock floor.

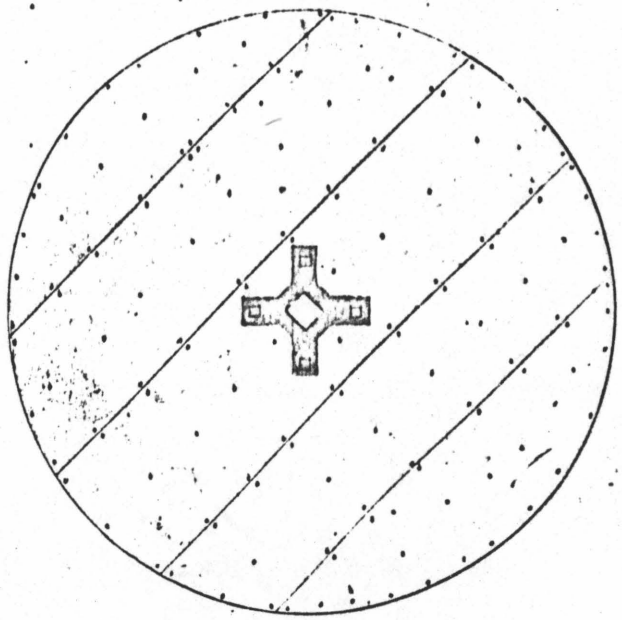
Photograph courtesy of the William L. Clements Library, University of Michigan, Ann Arbor.

Tread Wheel for a Driving Machine.

Scale 1½ inches to a Foot.

Jan. 1828.





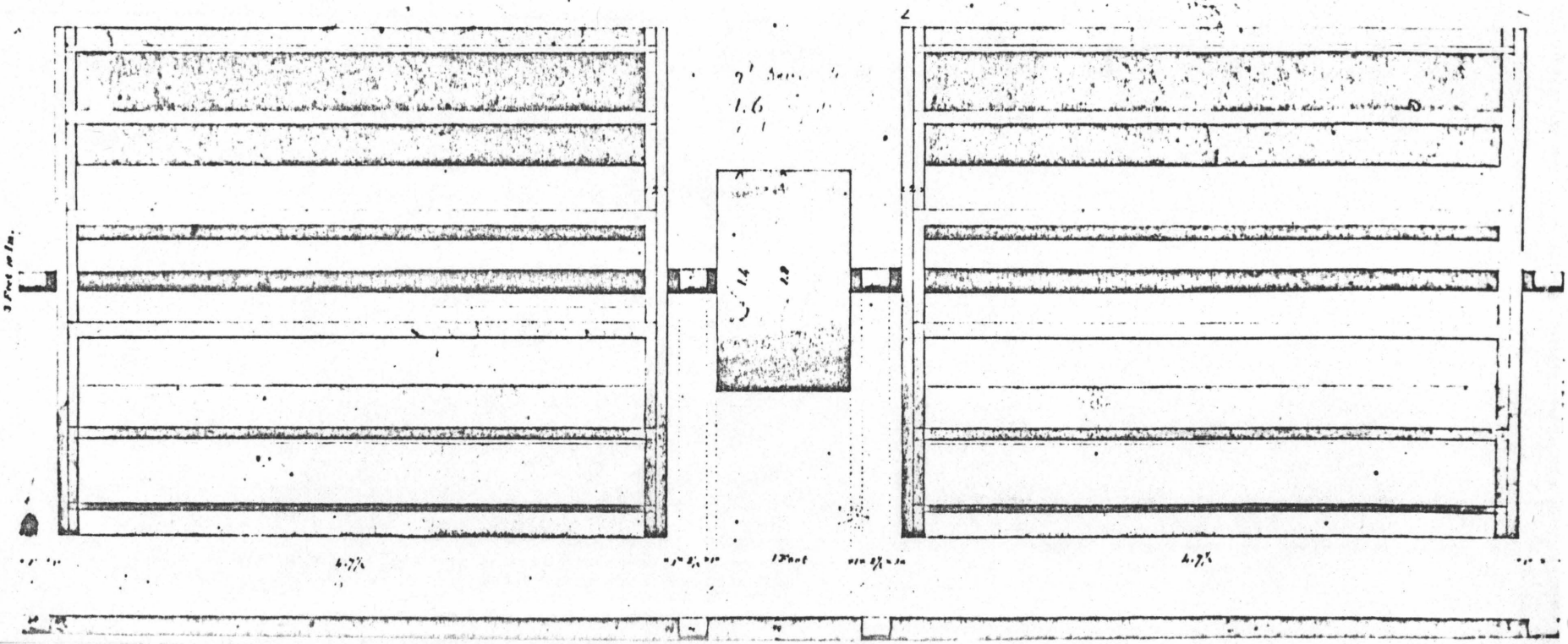
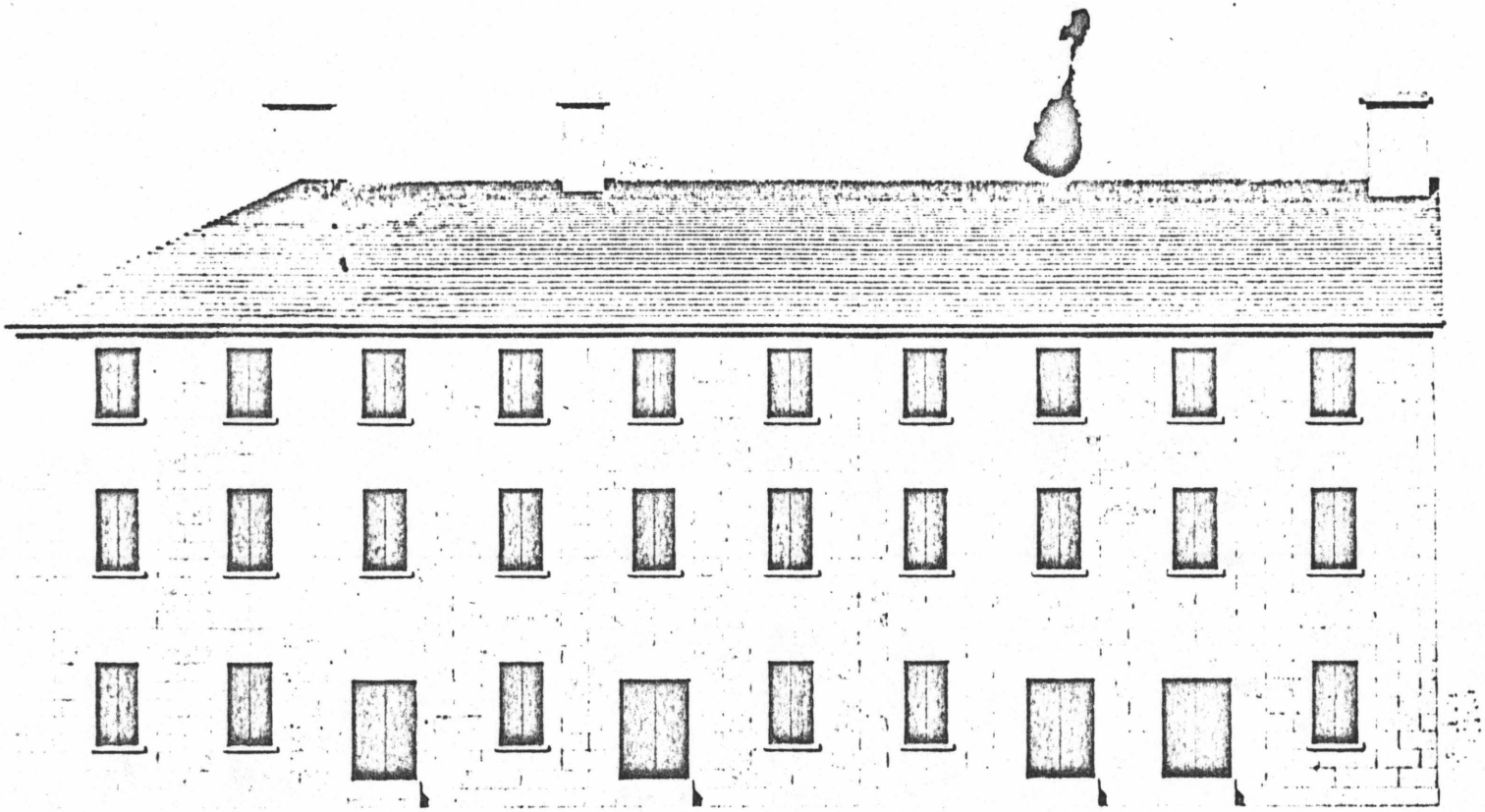


ILLUSTRATION NO. 9

"Southwest Elevation." This elevation is apparently an early design for the Dry Dock Engine House. The building was designed by Alexander Parris and there are slight variations between this drawing and the building as constructed. This may be due to the fact that construction of the building was delayed because the stonehammerers were working on the building's site. Design changes could easily have been made during this period of delay.

Photograph courtesy of the William L. Clements Library, University of Michigan, Ann Arbor.



SOUTH WEST ELEVATION.

Scale, 8 Ft. to 1 Inch.

Dry Dock Office, Charlestown, April 4. 1829.

East

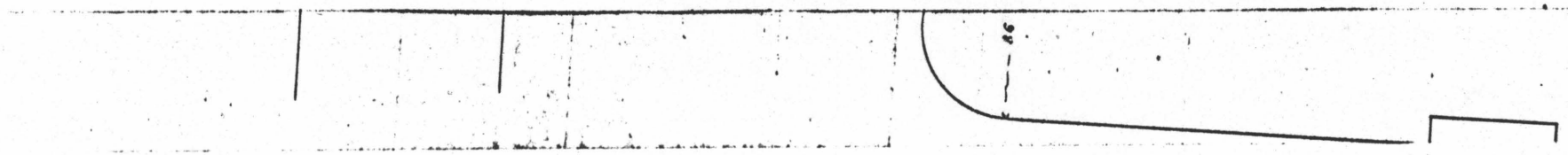
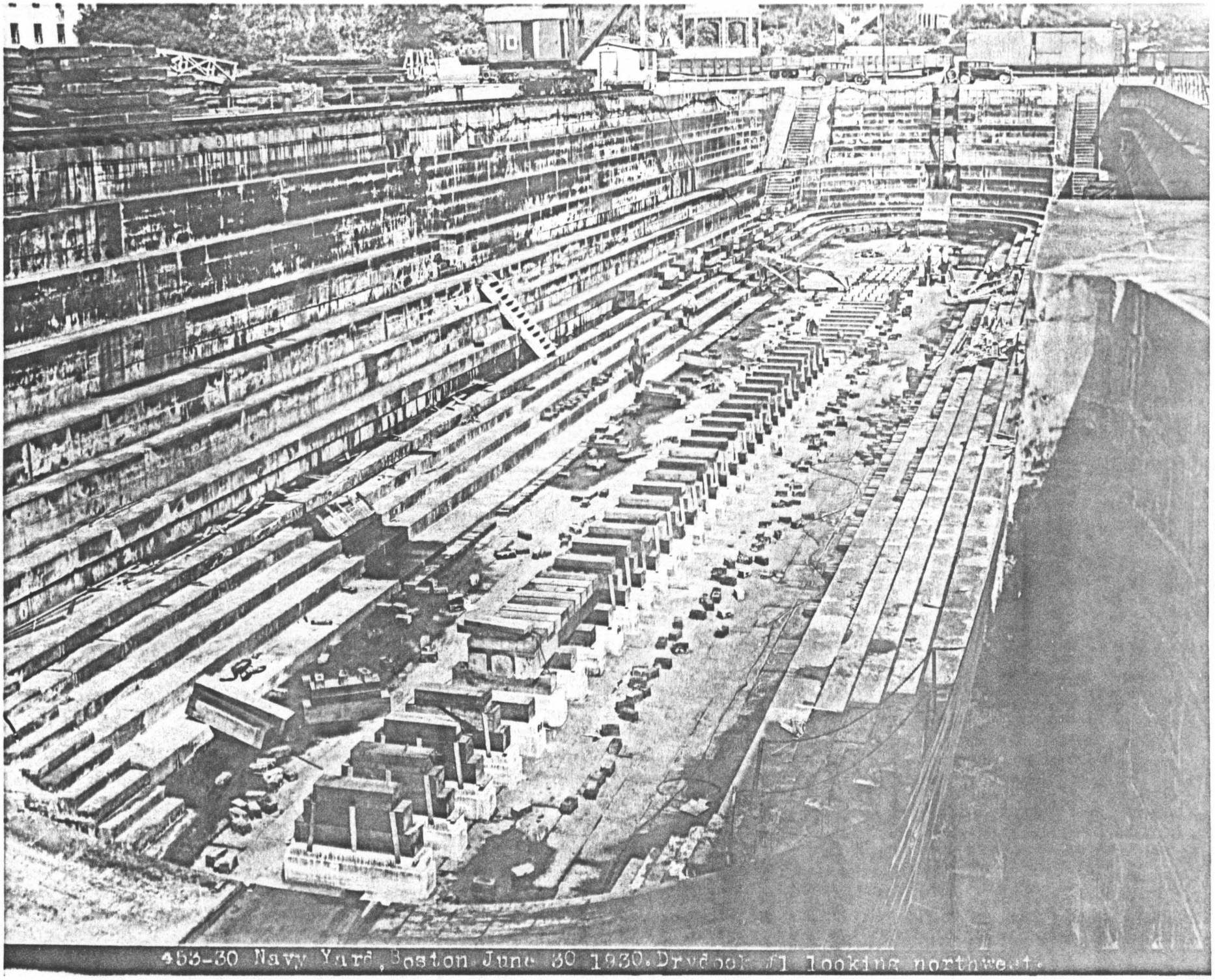


ILLUSTRATION NO. 10

"Dry Dock #1 looking northwest," June 30, 1930. This view indicates the full length of the Dry Dock before the outboard extension of 1947. The entrance arch is intact as are the timber ladders on the sidewall of the Dock. The keel blocking in the Dry Dock is in the process of being replaced.

Photograph courtesy of Boston National Historical Park, National Park Service.



453-30 Navy Yard, Boston June 30 1930. Drydock #1 looking northwest.

ILLUSTRATION NO. 11

Head of Dry Dock 1, Charlestown Navy Yard, Boston National Historical Park. This photograph shows the timber slides at the head of the Dock before they were altered. Mechanical systems have yet to be installed and the graceful curve of the head of the dock floor is intact. The inscription in the uppermost courses of the stonework registers the dates of the Dry Dock's construction and those responsible.

Photograph courtesy of Boston National Historical Park, National Park Service.

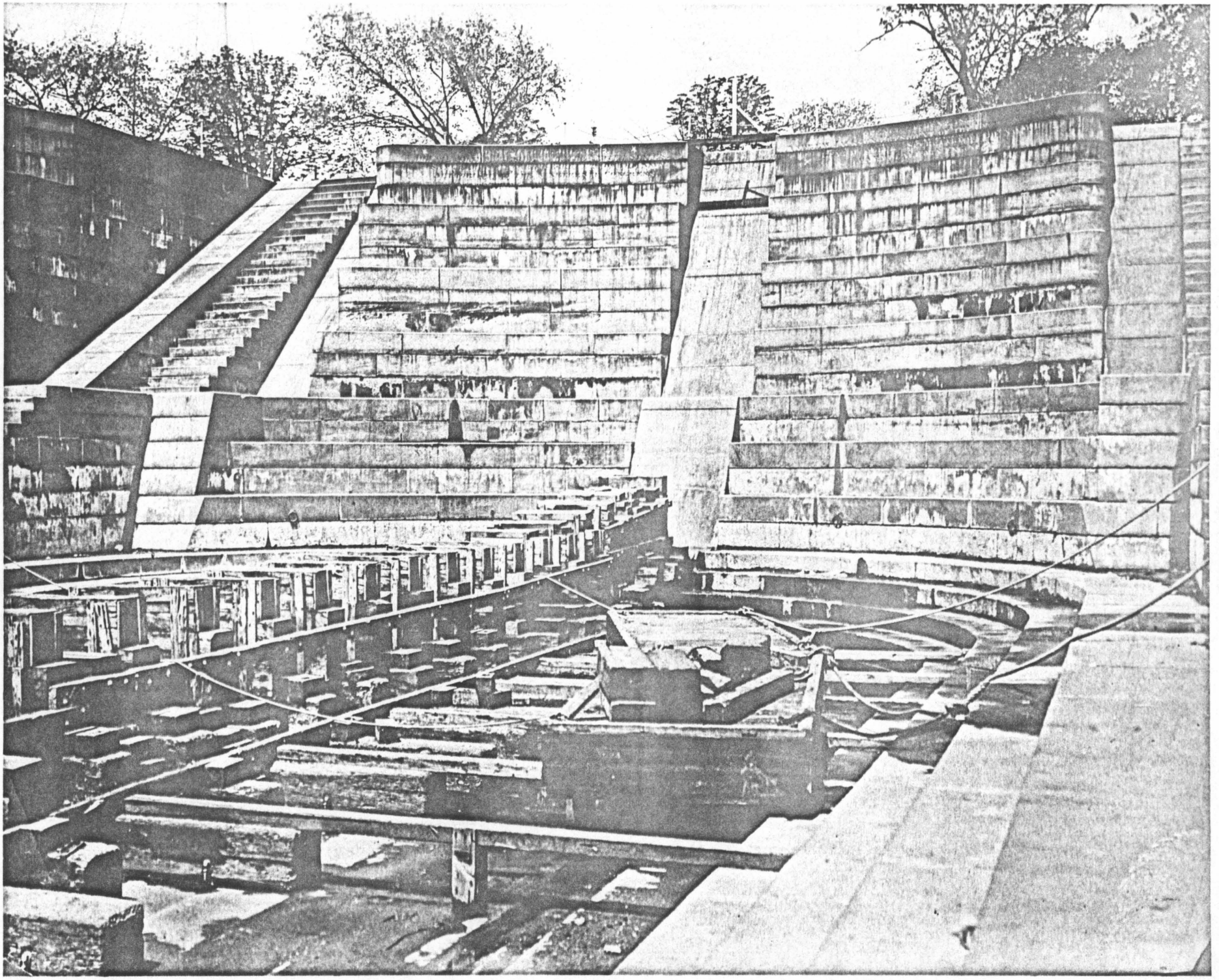


ILLUSTRATION NO. 12

Dry Dock 1, East Wall, Outboard End, early 20th Century.

This photograph records the original configuration of the lower end of Dry Dock 1. The curved area of the masonry wall was where the turning gates were located. The opening in the entrance arch, filled with concrete, was the conduit for the chains that opened and closed the gates. Note the capstans above. These were manually operated with a winch. The capstan in the center of the photograph was used to pull the chains to close the gates while the one closer to the caisson was used to open them.

Photograph courtesy of Boston National Historical Park, National Park Service.

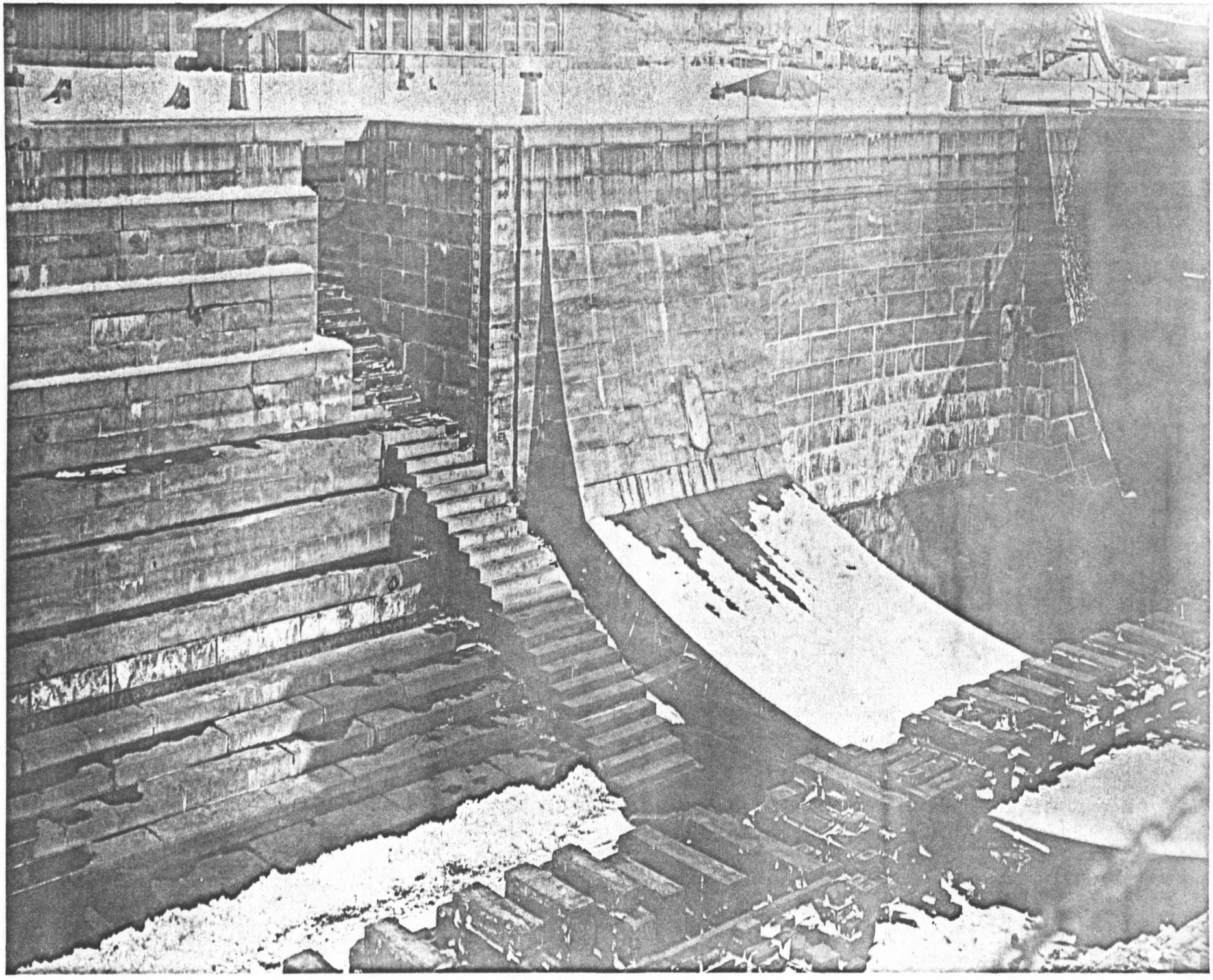


ILLUSTRATION NO. 13

Dry Dock 1, Wing Wall, 1946. This is an excellent view of one of the original masonry wing walls. The stairway was removed in the early years of the 20th century. The filling culvert is to the left of the stairs. The mechanism used to open the composition gate can be seen but the actual opening has been filled with concrete.

Photograph courtesy of Boston National Historical Park, National Park Service.

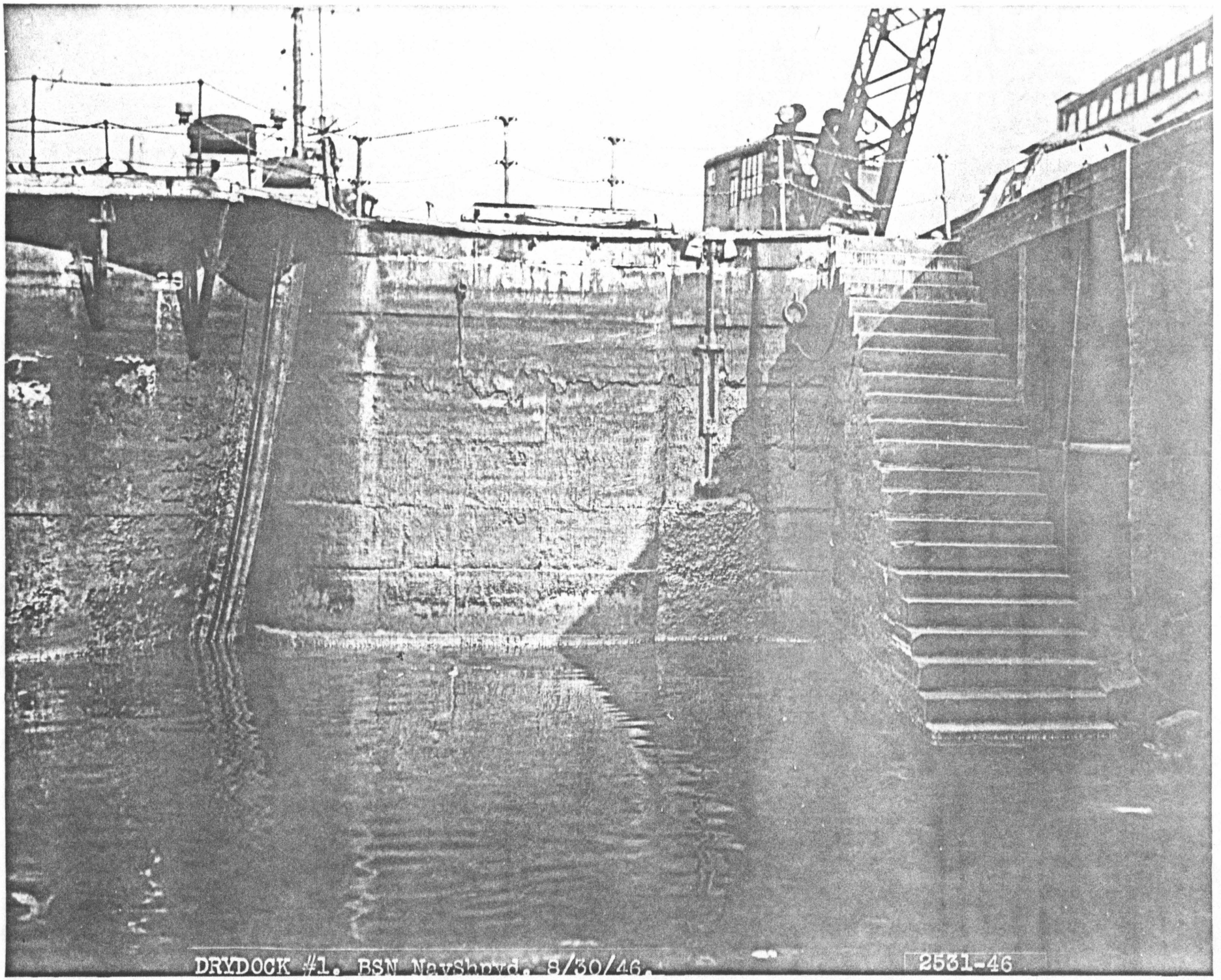

DRYDOCK #1. BSN NavShpyd. 8/30/46.
2531-46

ILLUSTRATION NO. 14

Entrance to Dry Dock 1, 1946. Clearly the mitre sill and the adjacent area had been altered by the time this photograph was taken. The basic configuration of the original Dock entrance can still be seen, however. Baldwin's design for the Dry Dock called for the turning gates to rest against the pointed mitre sill which resisted the pressure of the tide. Both sets of granite steps at the lower end of the Dock are visible in this view.

Photograph courtesy of Boston National Historical Park, National Park Service.

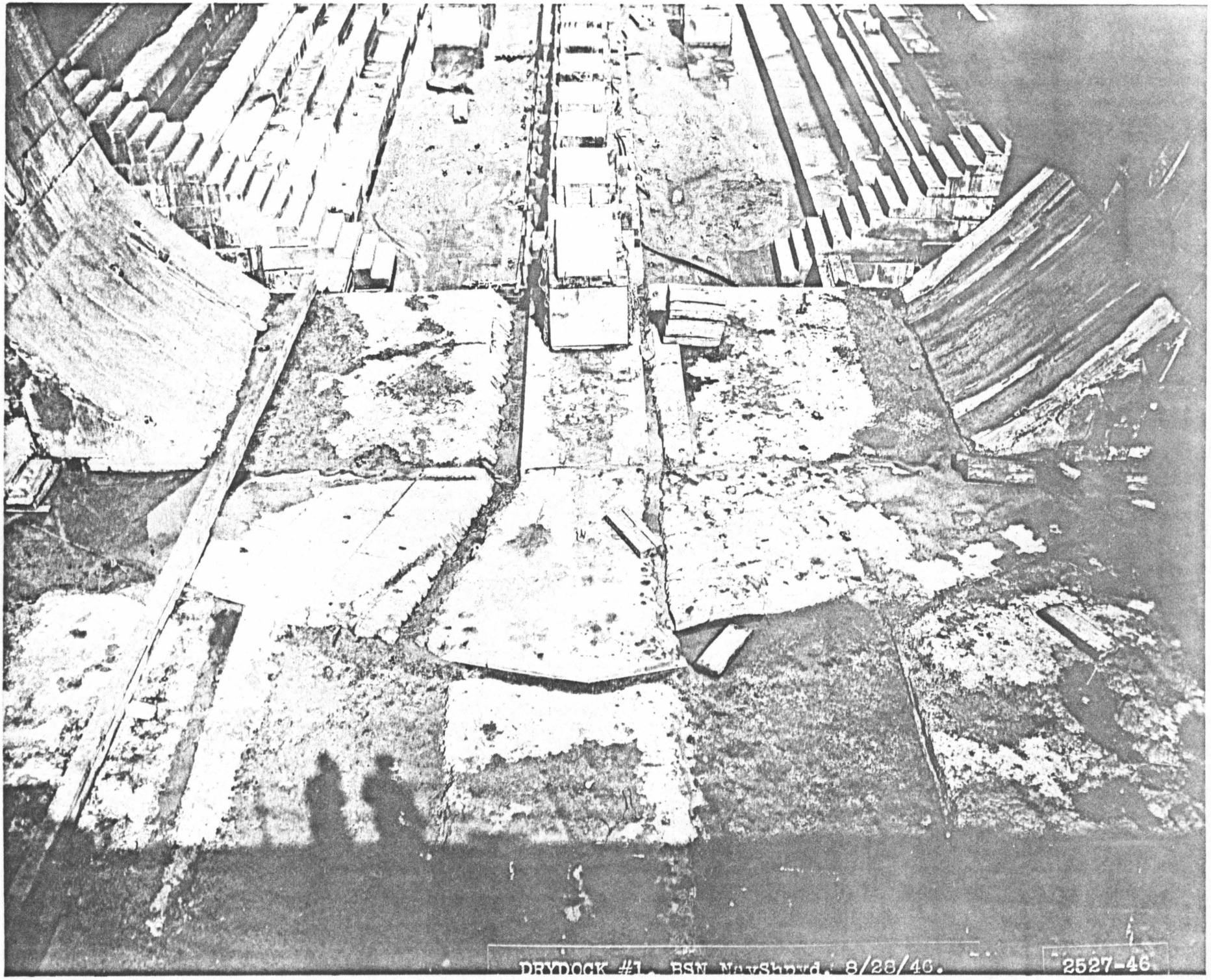

DRYDOCK #1. BSN Marshard. 8/28/46.
2527-46

ILLUSTRATION NO. 15

East Wall, Dry Dock 1, 1946. The severe displacement of stones which necessitated the relaying of the upper portion of the Dry Dock walls is well illustrated in this photograph. Rebuilding of the top four altars was undertaken when the Dock was extended in 1947.

Photograph courtesy of Boston National Historical Park, National Park Service.

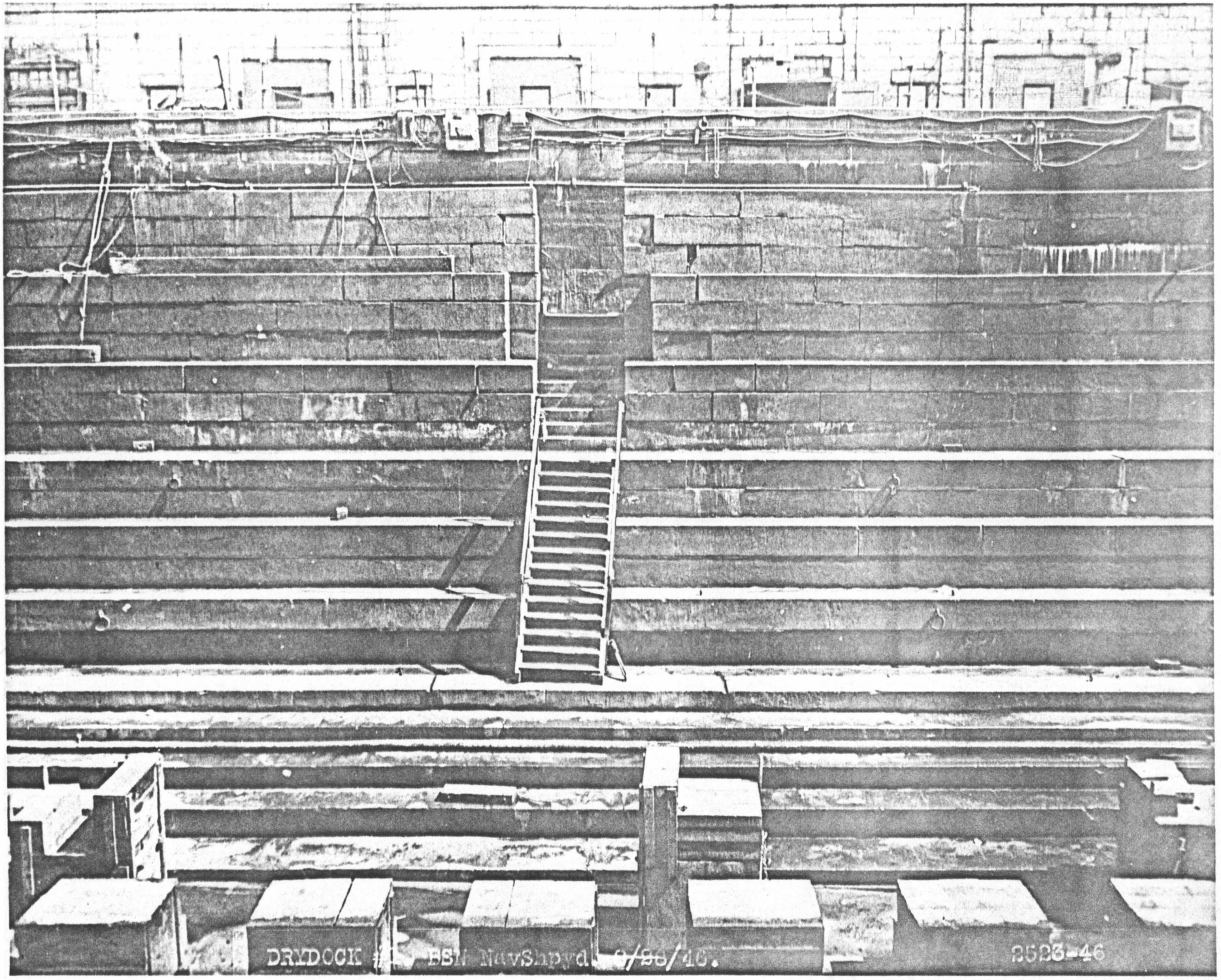

DRYDOCK #1 - BSH NavShpyd 9/28/46.
2528-46

ILLUSTRATION NO. 16

Extension of Dry Dock 1, 1947. In 1947 Dry Dock 1 was extended seaward. The original masonry wing walls were removed and a cofferdam and walls of steel sheetpiling were driven to keep the construction site dry. The extension of the Dock was primarily of reinforced concrete. The formwork for the concrete can be seen in this view.

Photograph courtesy of Boston National Historical Park, National Park Service.

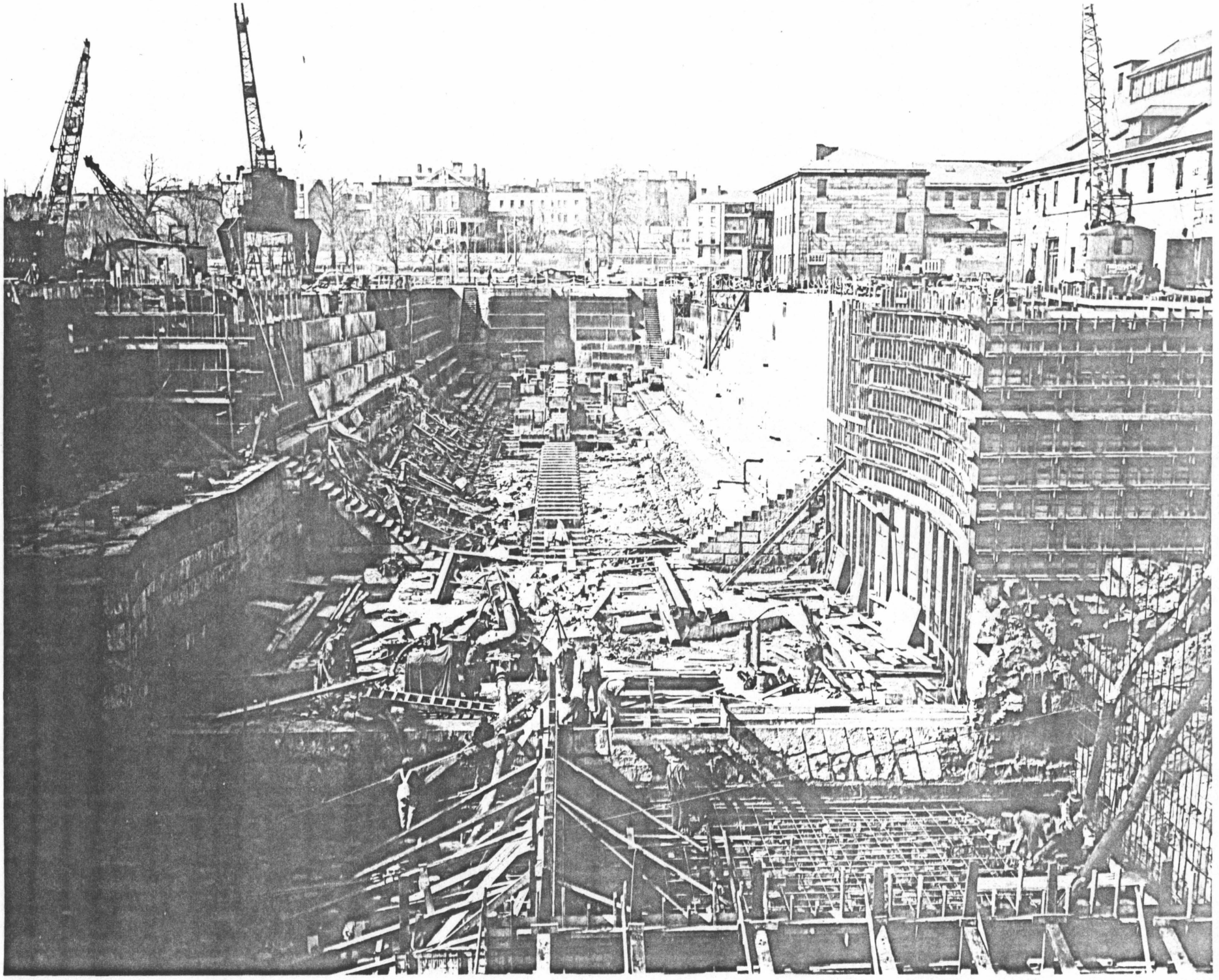


ILLUSTRATION NO. 17

Dry Dock 1, Detail, West Wall, 1948. Taken during the 1947 extension of Dry Dock 1, this photograph is an excellent section of the Dock's foundation. Piles were driven and topped with capsills. Rubble was used to fill in between the piles. A layer of plank flooring was laid upon the first row of timbers. A second layer of squared timbers was placed on top of the plank and the interstices were packed with brick masonry. A second plank floor was rested on the brick and carried the stonework of the Dry Dock.

Photograph courtesy of Boston National Historical Park, National Park Service.

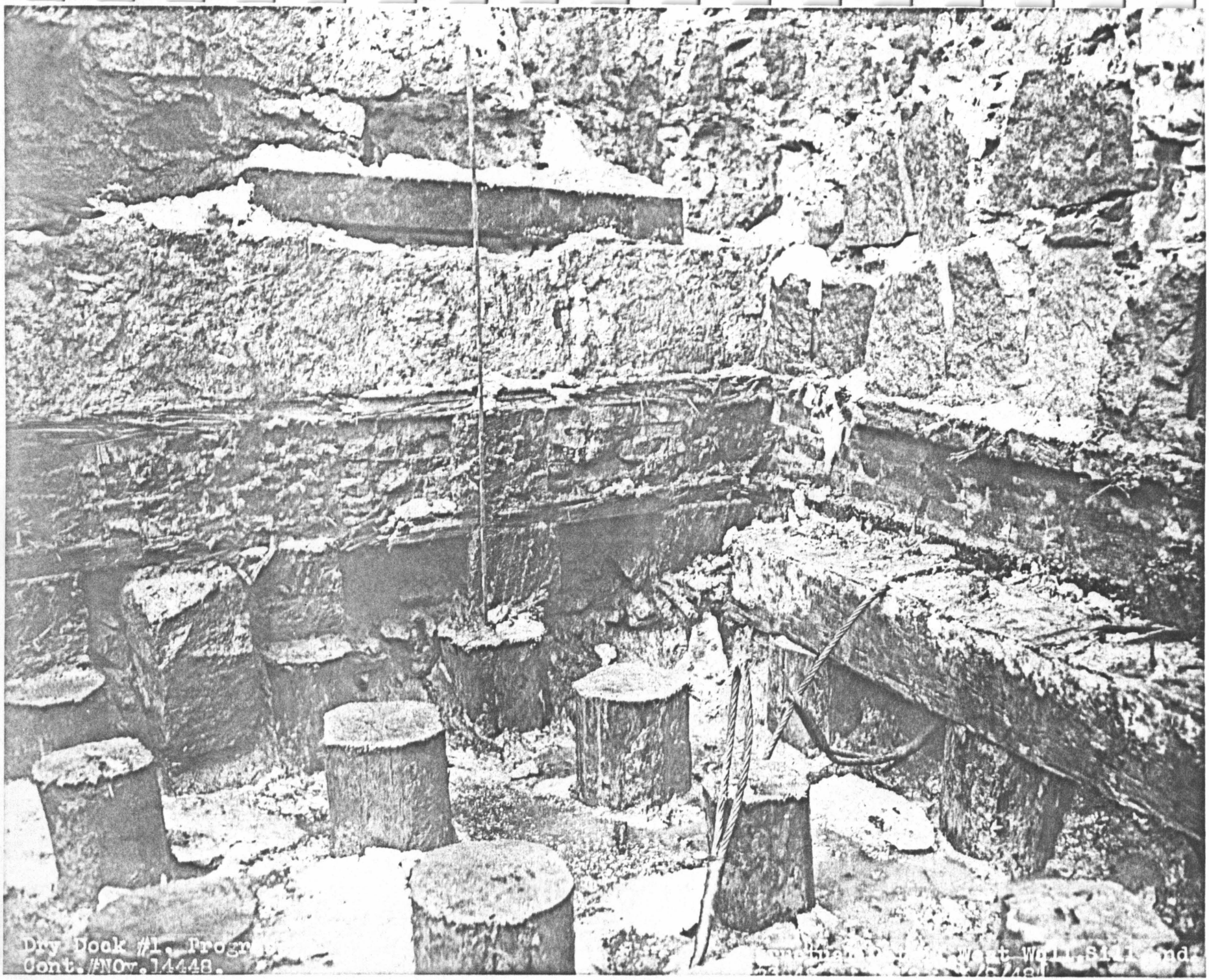

Dry Dock #1.
Cont. #NOw. 14448.

ILLUSTRATION NO. 18

Dry Dock 1, West Wall of Dock from East Side, 1947.

This photograph illustrates the extent to which the Dry Dock walls were rebuilt during the extension of 1947. Steel sheetpiling was driven behind the masonry walls and the top four courses of granite were relaid. Some rubble masonry backing behind the walls was replaced with reinforced concrete. The author was unable to determine the exact length of the sections of the Dock walls that were reconstructed.

Photograph courtesy of Boston National Historical Park, National Park Service.

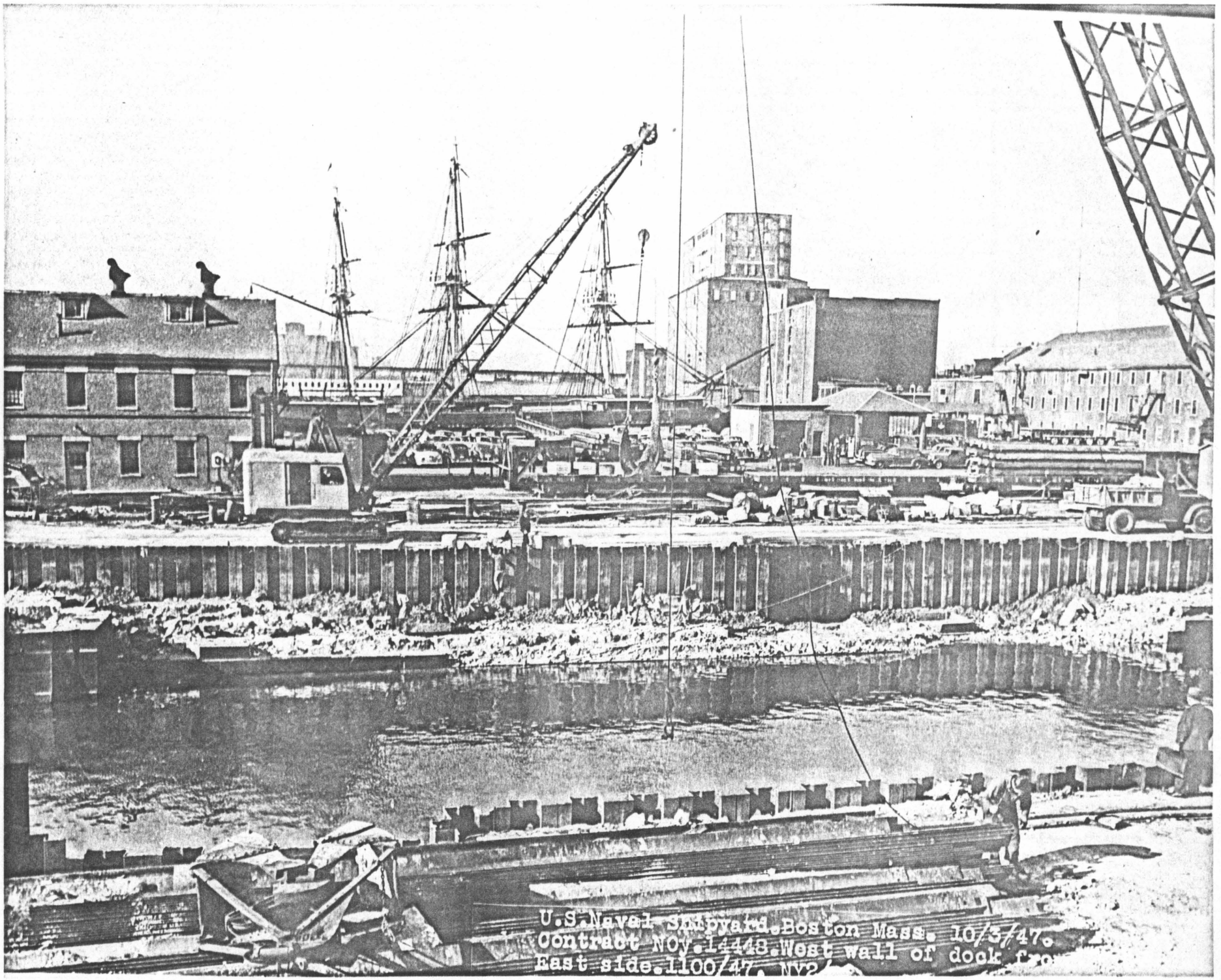

U.S.Naval Shipyard.Boston Mass. 10/3/47.
Contract NOy.14418.West wall of dock fro
East side.1100/47. NY2

ILLUSTRATION NO. 19

Dry Dock 1, View from North Centerline, 1948. This photograph shows the extension of the Dry Dock nearing completion. Note the steel sheetpiling cofferdam and the newly poured concrete walls at the outboard end of the Dock.

Photograph courtesy of Boston National Historical Park, National Park Service.

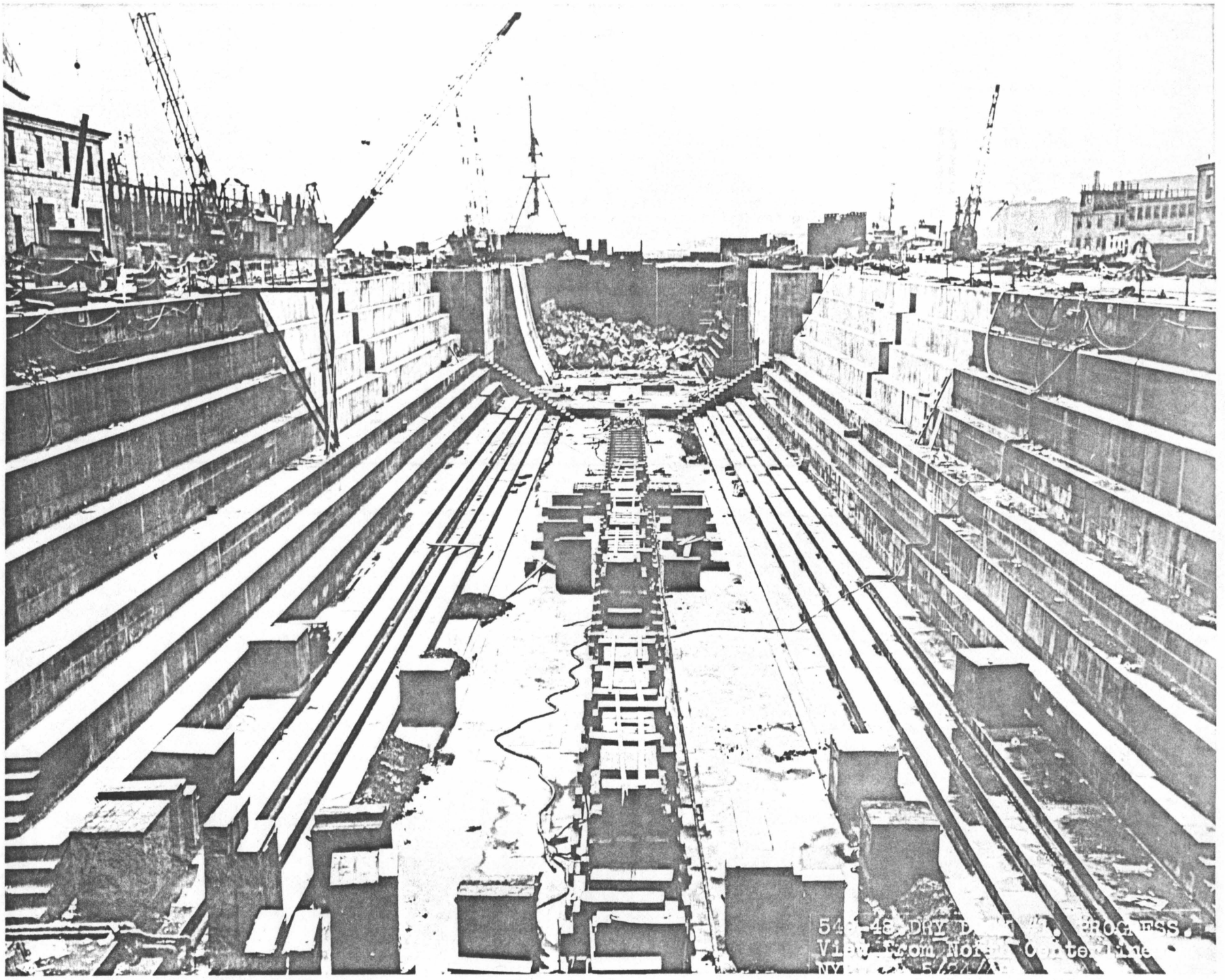


ILLUSTRATION NO. 20

Dry Dock 1, Improvement to Dewatering System, 1960.

In 1960 improvements to the drainage system of the Dock resulted in the removal of the stairs at the lower east side of the Dock. The stairs were replaced in concrete.

Photograph courtesy of Boston National Historical Park, National Park Service.

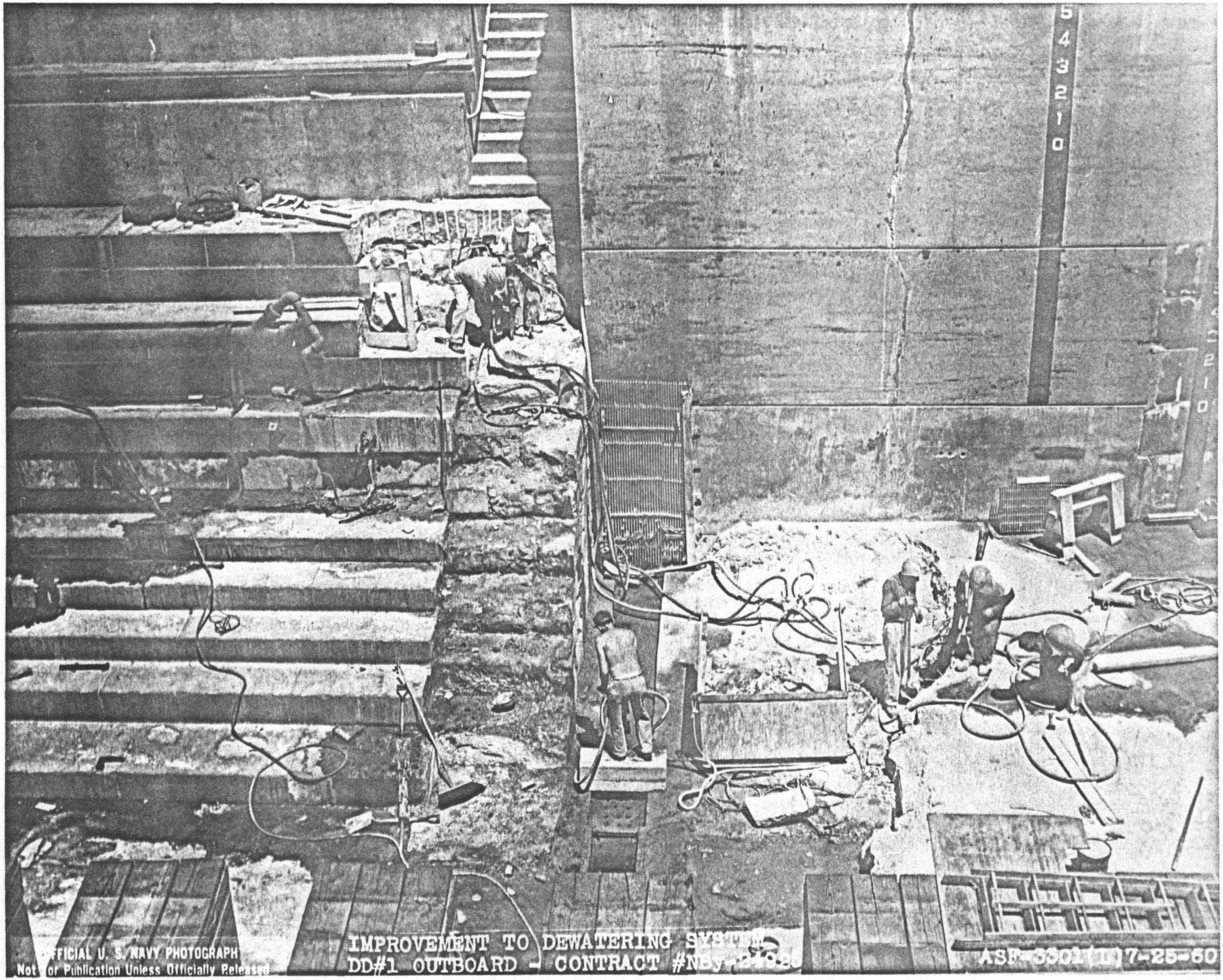

5 4 3 2 1 0
2 1 0
OFFICIAL U. S. NAVY PHOTOGRAPH
Not for Publication Unless Officially Released
IMPROVEMENT TO DEWATERING SYSTEM
DD#1 OUTBOARD - CONTRACT #N
ASF-3301 (11) 7-25-60

ILLUSTRATION NO. 21

Head of Dry Dock 1, Charlestown Navy Yard, Boston National Historical Park, 1979.

The head of the Dock has undergone many alterations in the past 150 years. The timber slide in the center was chopped out so that the Dock could accommodate larger vessels. The inscription in the top courses reads:

Commenced July 10, 1827.
John Q. Adams President of the United States,
Samuel B. Southard Secretary of the Navy,
Authorised by the Nineteenth Congress

Opened 24 June, 1833.
Andrew Jackson President of the United States
Levi Woodbury Secretary of the Navy
Loammi Baldwin Engineer

Photograph taken by the author.

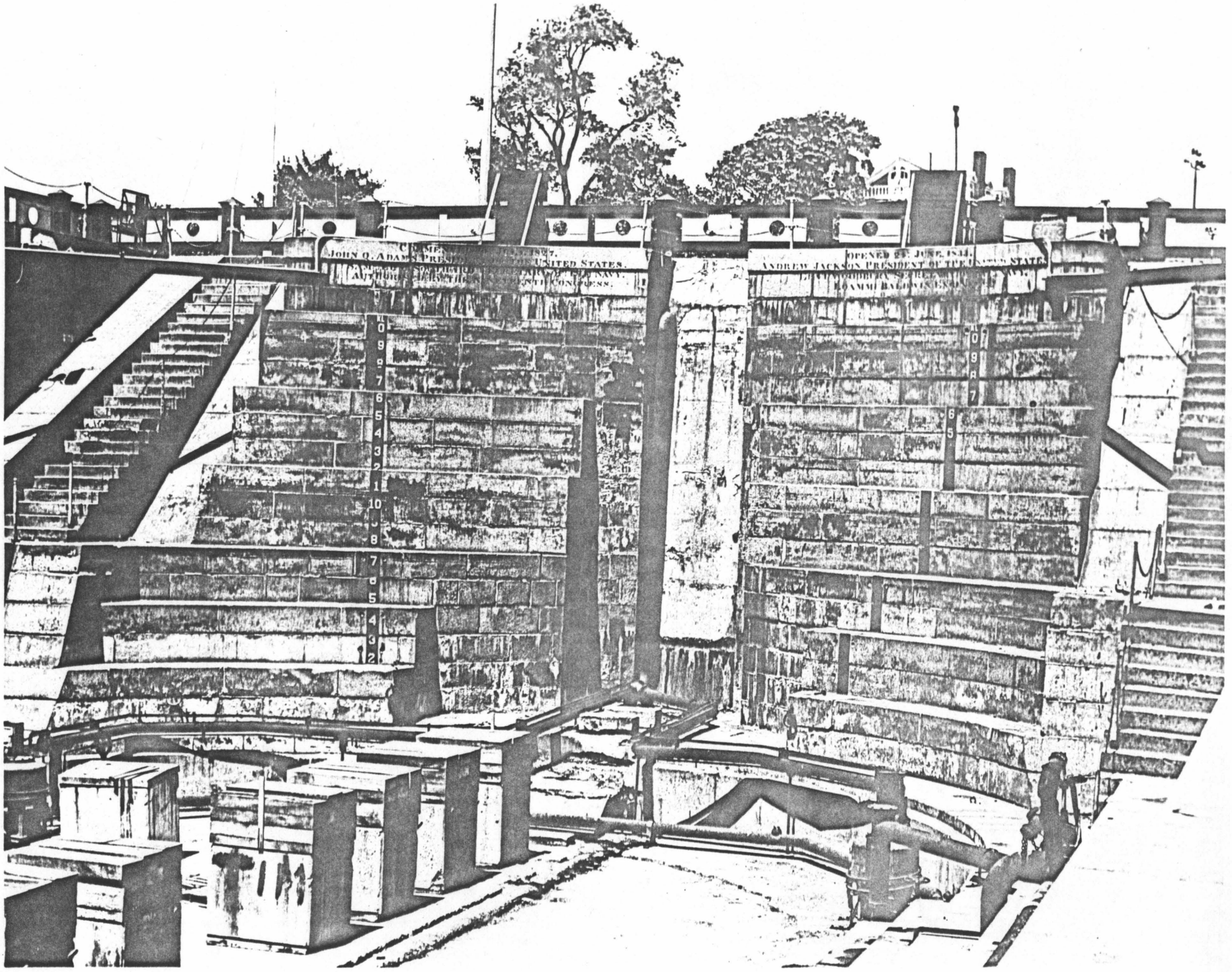

JOHN Q. ADAMS PRES.
UNITED STATES.
OPENED 21 JUNE 1834.
ANDREW JACKSON PRESIDENT OF THE UNITED STATES

ILLUSTRATION NO. 22

Dry Dock 1, West Wall, 1979. The difference between the sizes in the granite stones in this photograph marks the line of the 1858 extension of the Dock. At that time the head of the Dock was taken down and rebuilt 65 feet further inland. The infill stones were equal to two courses of the original masonry.

Photograph taken by the author.

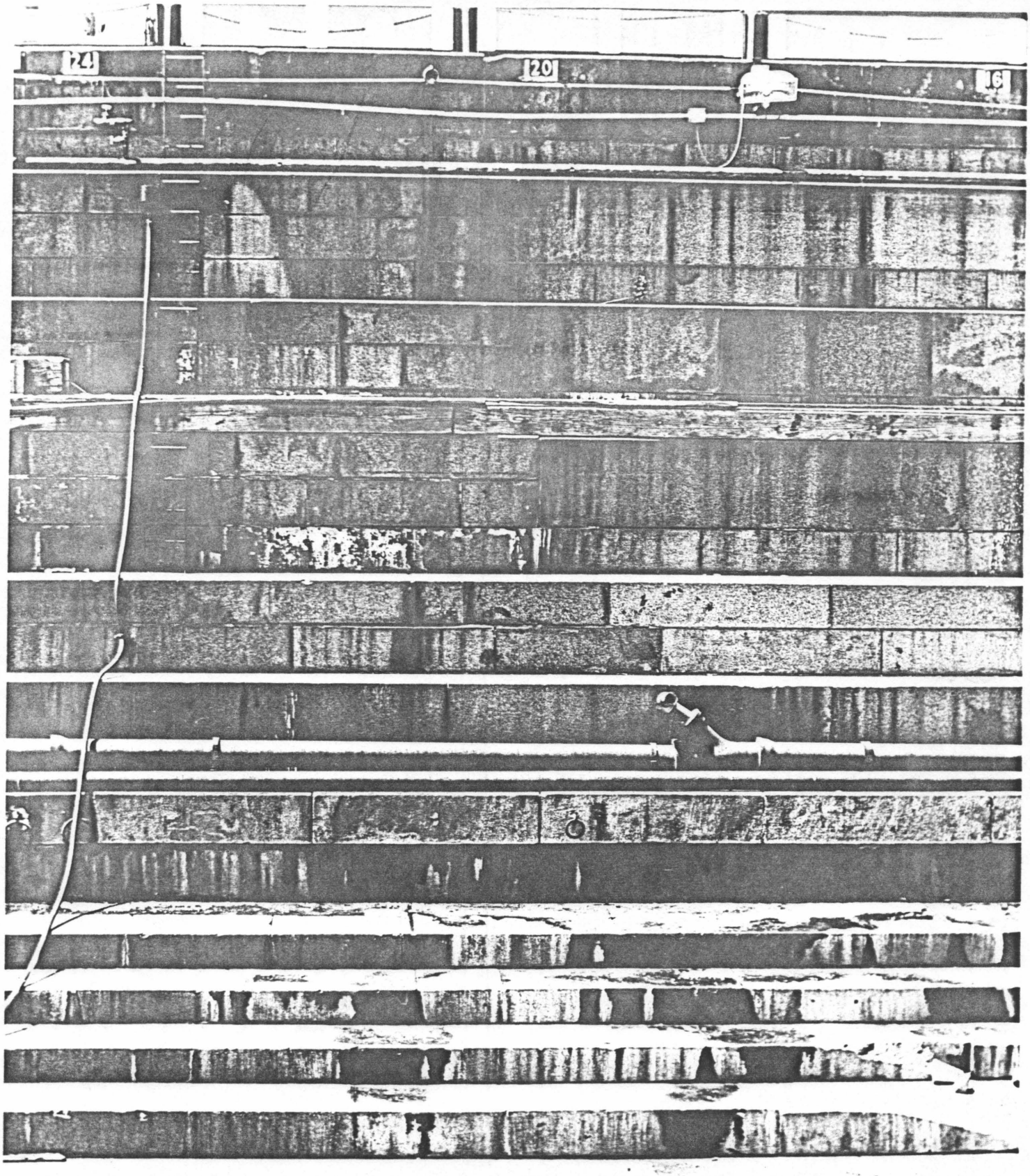

24
20
16

ILLUSTRATION NO. 23

Dry Dock 1, Chamber Floor, 1979.

The ghost of the original location of the head of the Dock can easily be seen in the difference between the stones on the chamber floor.

Photograph taken by the author.

ILLUSTRATION NO. 24

Dry Dock 1, Stairway, West Wall.

The original granite stairway is still in place on this side of the Dock although the stairway on the east side at the lower end has been replaced in concrete. Some settlement of the stones are evident and the joints are in need of repointing.

Photograph taken by the author.

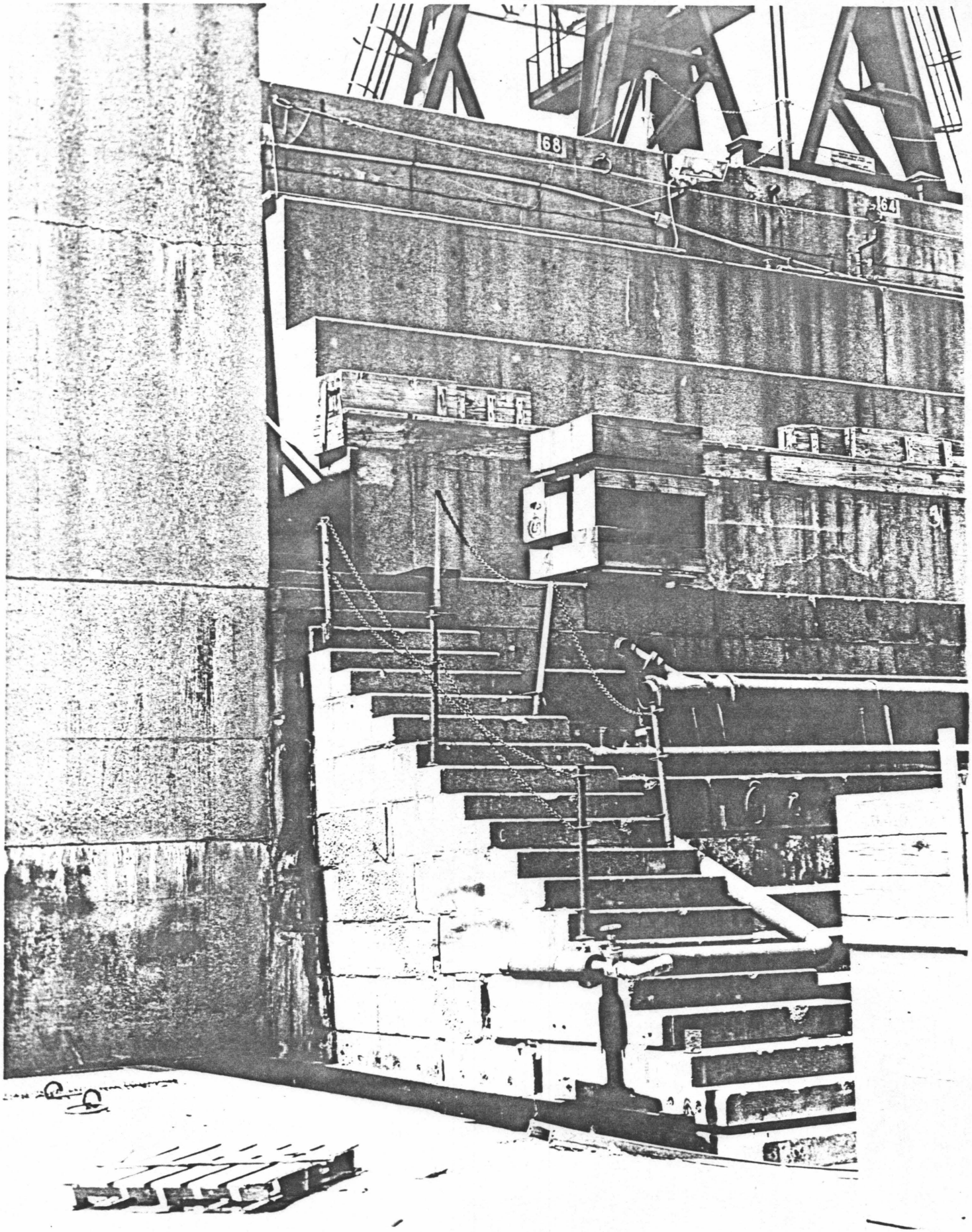

68
64

ILLUSTRATION NO. 25

Pier 1, Navy Yard, Boston, 1903.

This photograph was taken during the construction of Pier 1 at the Navy Yard. It is of interest because, in the foreground a timber floating gate is moored to the pier. This is the indigent Dry Dock caisson which had been recently replaced by one of steel construction.

Photograph courtesy of Boston National Historical Park, National Park Service.

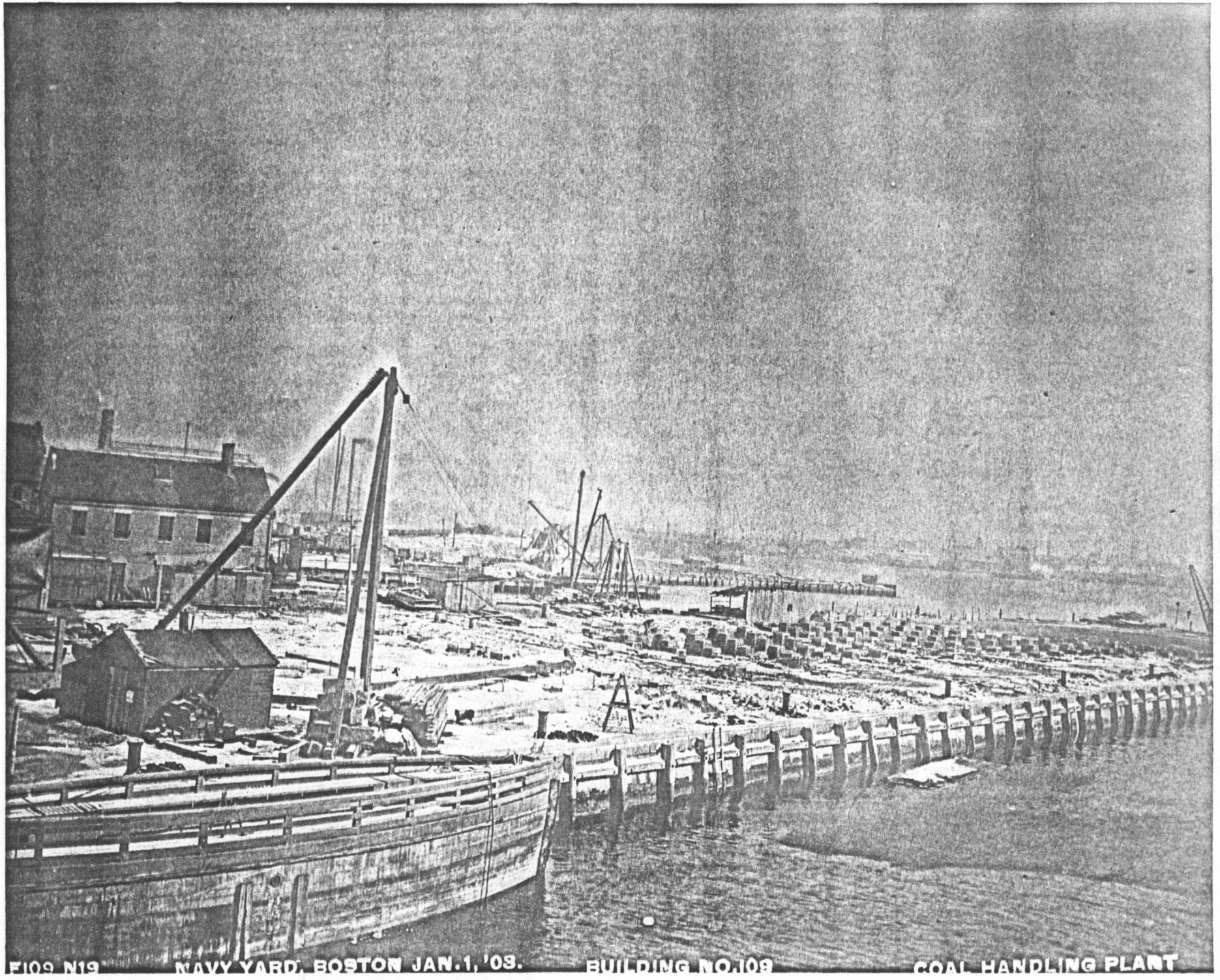

F109 N19
NAVY YARD, BOSTON JAN. 1, '03.
BUILDING NO. 109
COAL HANDLING PLANT

ILLUSTRATION NO. 26

"Caisson for Dry Dock, Boston Navy Yard, Oct. 31, 1901."

The new steel caisson for Dry Dock 1 was launched in 1901. It had been constructed in the previous year and replaced a timber floating gate. This caisson is still in use in Dry Dock 1 today, having been rebuilt several times.

Photograph courtesy of Boston National Historical Park, National Park Service.

4

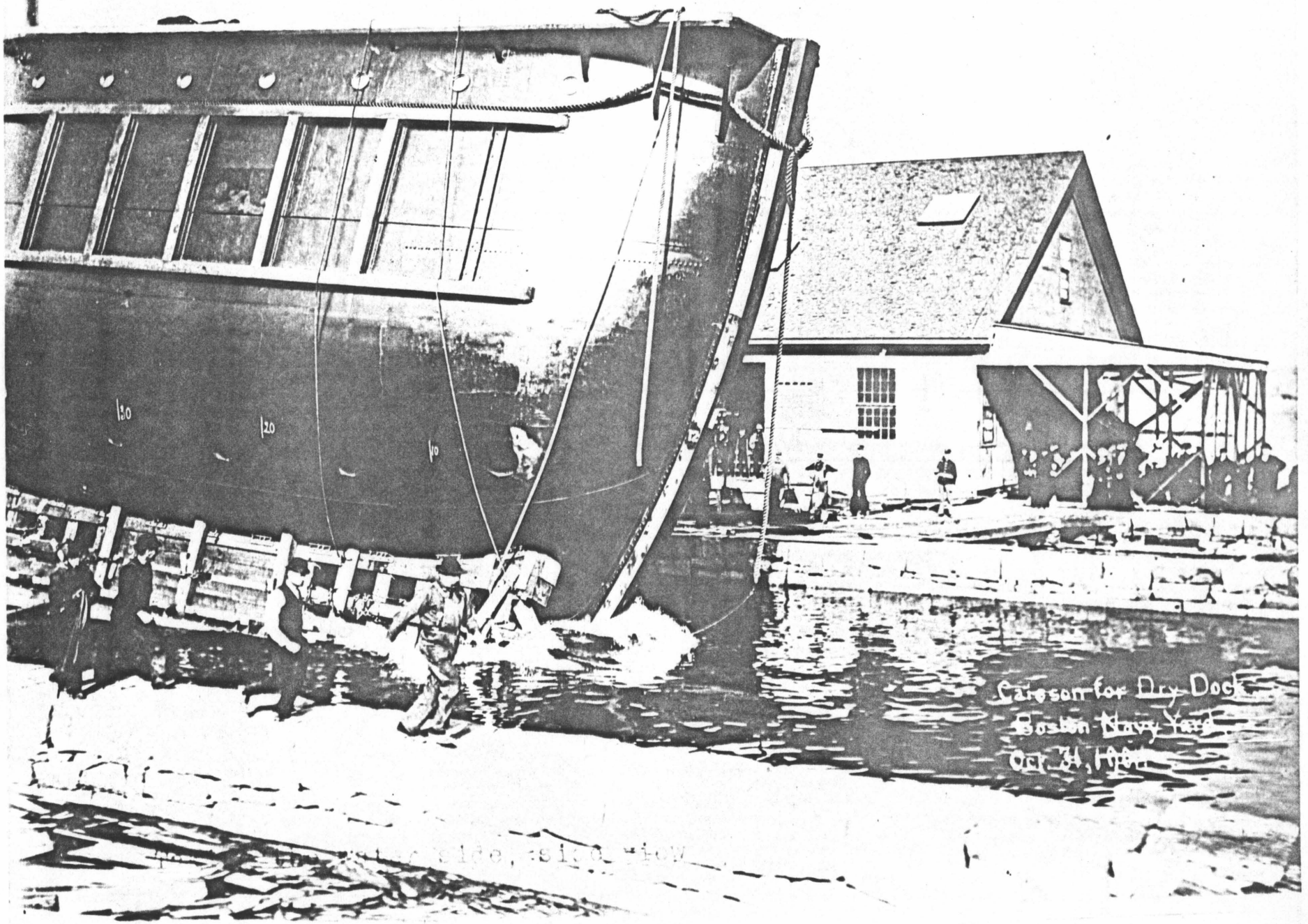


ILLUSTRATION NO. 27

Dry Dock 1, Caisson and Outboard End, 1979.

The Dry Dock caisson, built in 1901, has been rebuilt several times. The concrete walls on either side of the caisson date from the 1947 extension of the dock.

Photograph taken by the author.

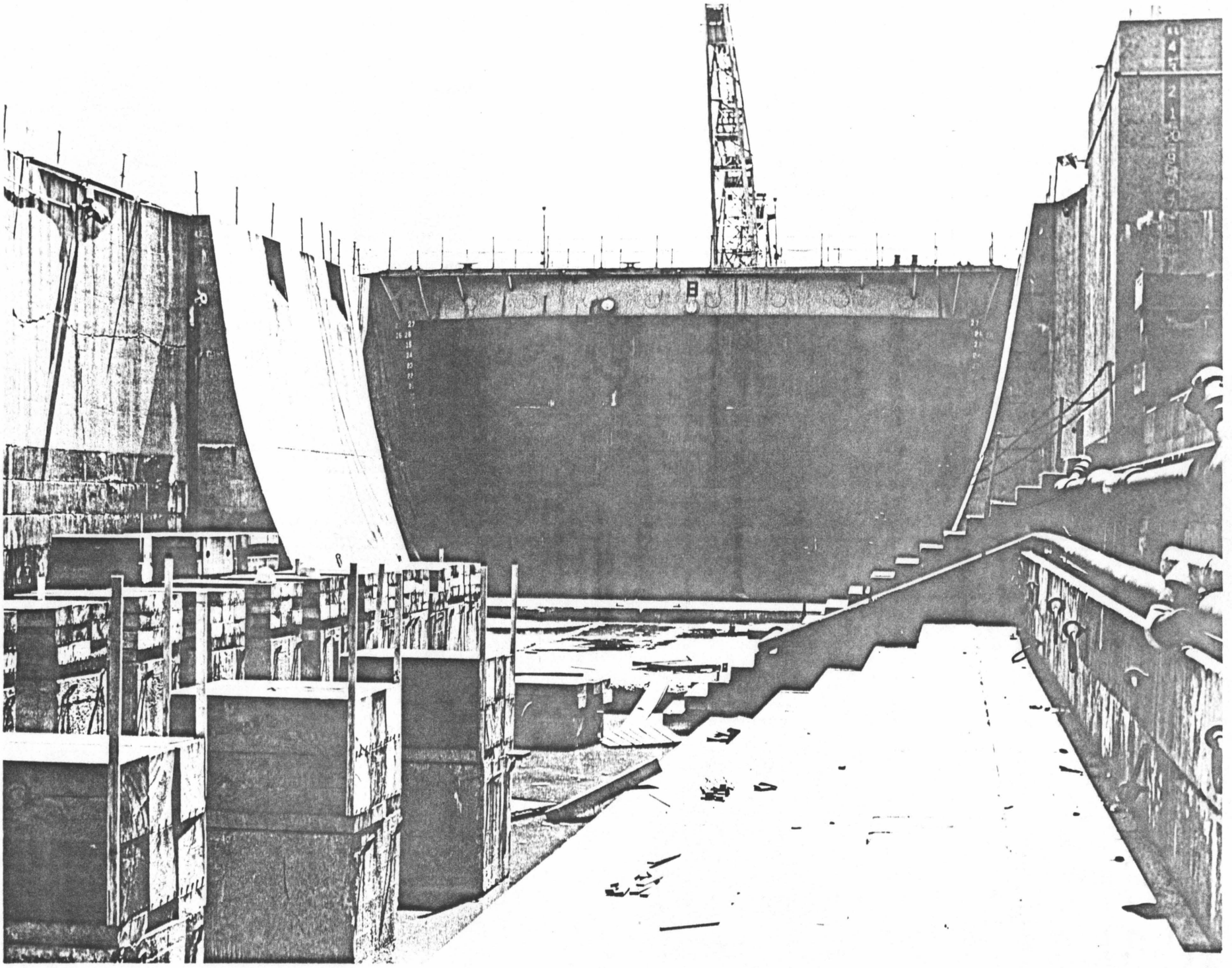
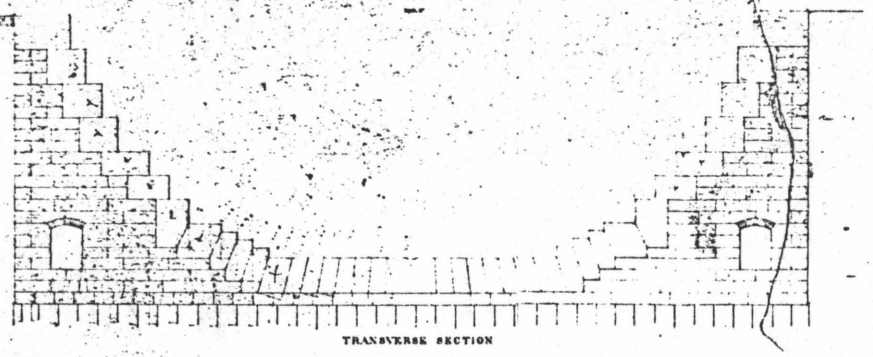


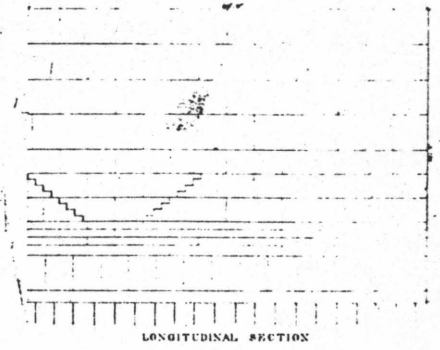
ILLUSTRATION NO. 28

"Proposed Plan for Extending the Dry Dock at U.S. Navy Yard, Boston," 1856. Although the original proposal was to extend the Dry Dock 50 feet in 1856 it was actually increased 65 feet in length. This drawing was included with the Annual Report and Estimates for the Fiscal Year 1856 sent to the Secretary of the Navy.

Courtesy of Boston National Historical Park, National Park Service.



TRANSVERSE SECTION



LONGITUDINAL SECTION

G

Proposed Plan

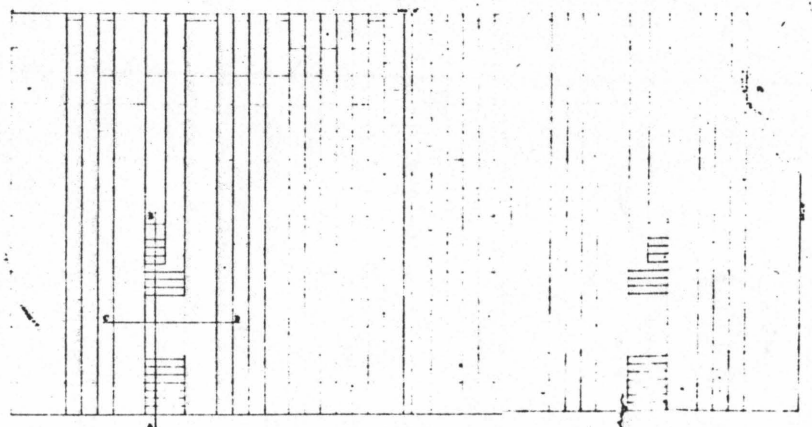
FOR EXTENDING THE DRY DOCK

at

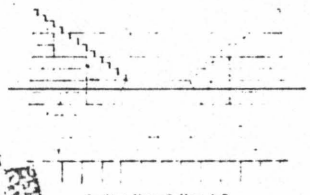
U.S. NAVY YARD, BOSTON

FIFTY FEET IN LENGTH.

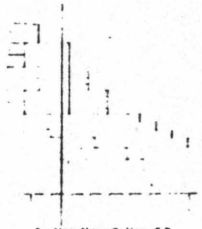
July 28th 1856.



PLAN



Section through line A B



Section through line C D

ILLUSTRATION NO. 29

Section of the Great Draining Wells, August 1833. This drawing shows eight of the pumps originally used to pump the water from the Dry Dock out into the river. Each of the two wells is shown in section with two lift pumps and two chain pumps, the chain pumps being those on the inside. There were actually sixteen pumps originally, eight of each type. The chain pumps, difficult to maintain in working order, were used for only a short period of time.

Courtesy of Boston National Historical Park, National Park Service.

Longitudinal Section on C.D
of the
Great Straining Wells
Bedfy. August 1833. Scale ½ inch = 1 foot

E271-24.

ILLUSTRATION NO. 30

"Old Steam Engine for Dry Dock," undated. This drawing illustrates one of the 19th century Dry Dock Engines. It is most likely the engine used during the second half of the century rather than the earlier engine designed by Ebenezer Lester when the Dock was built.

Courtesy of Boston National Historical Park, National Park Service.

ASI

Hill Steam Engine for Dry Dock

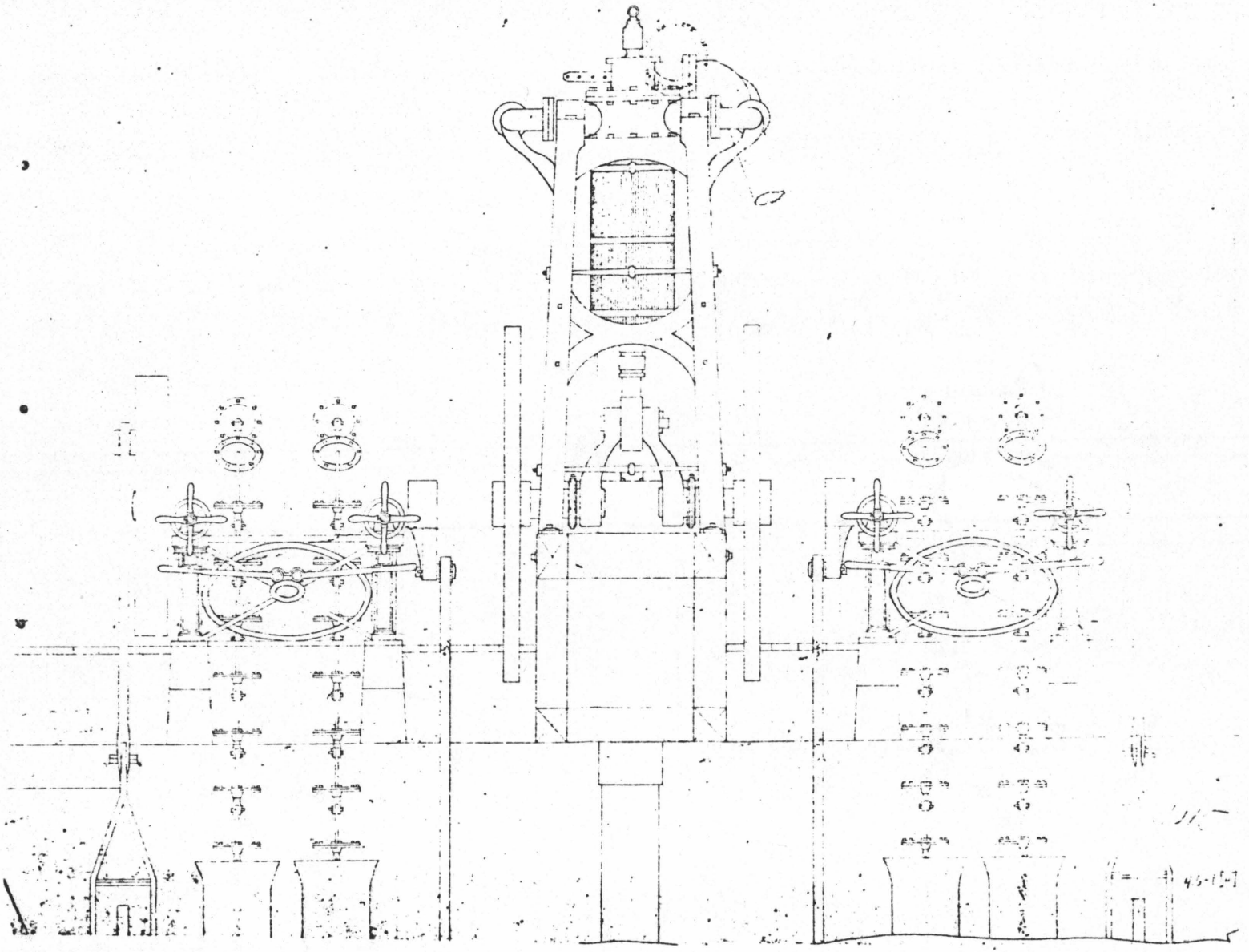
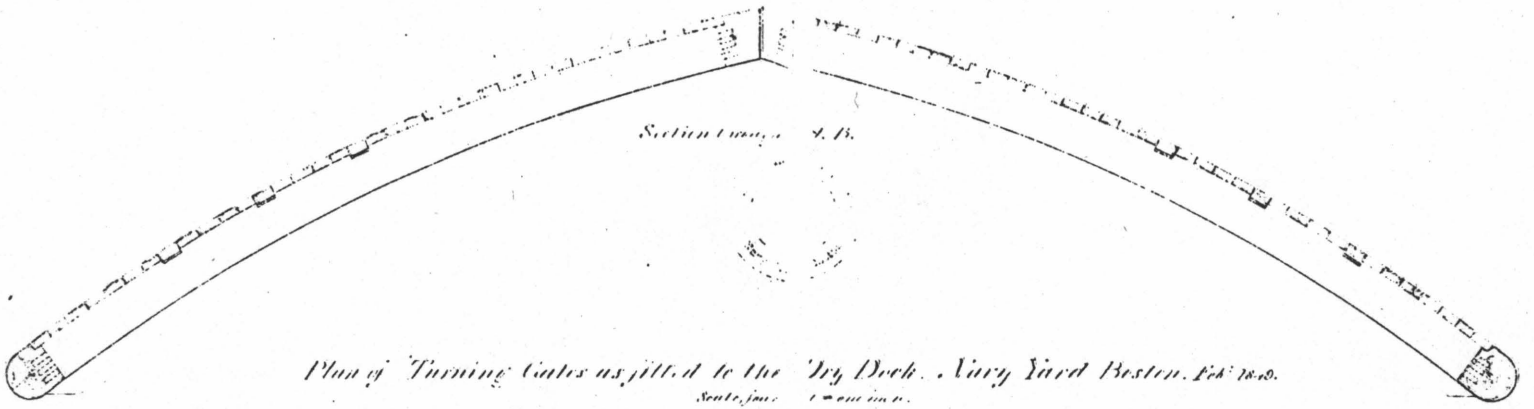


ILLUSTRATION NO. 31

"Plan of Turning Gates as fitted to the Dry Dock, Navy Yard Boston, Feb. 1949." This drawing illustrates the timber turning gates used in the Dry Dock until the late 19th century. The gates travelled on rollers and were opened and closed by manually operated capstans.

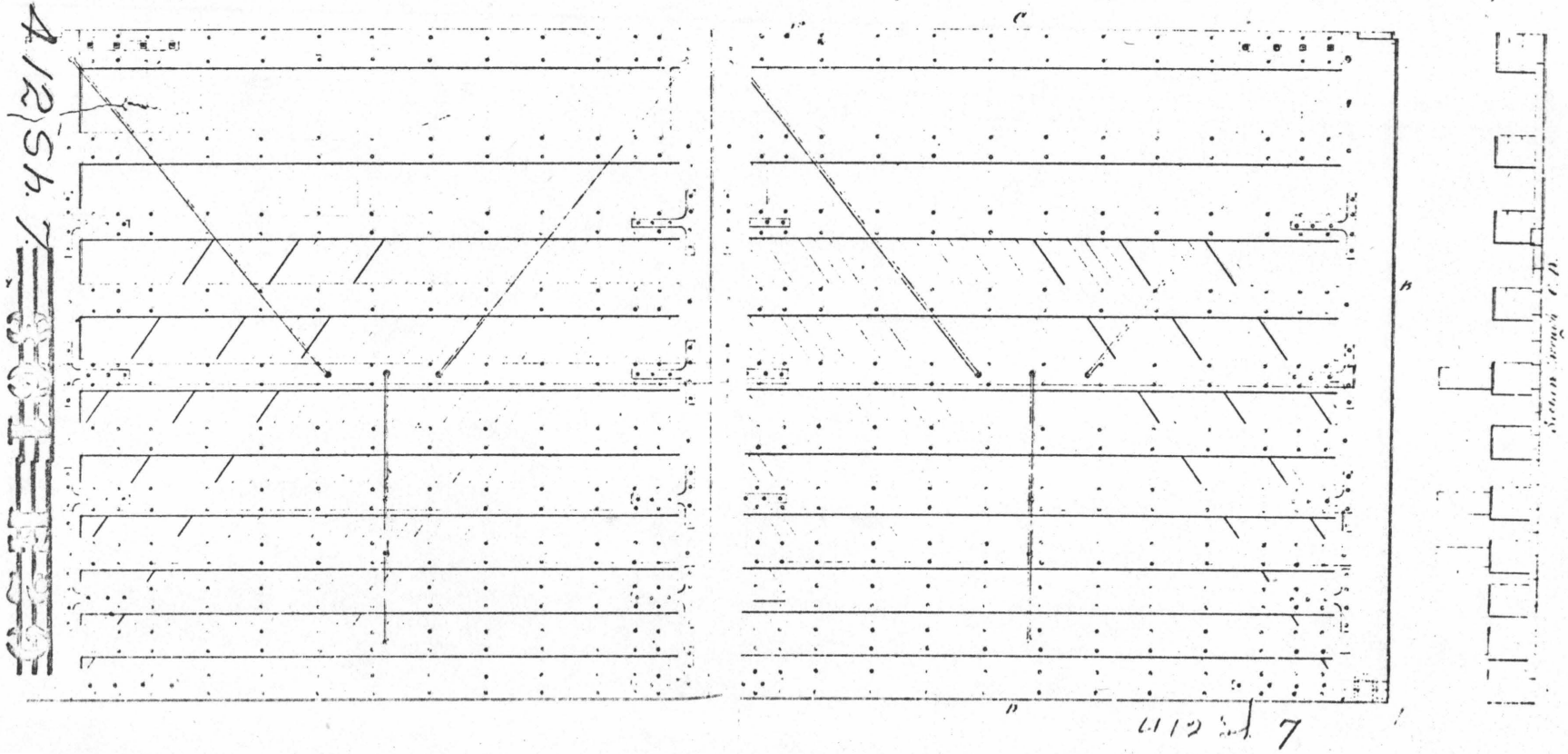
Courtesy of Boston National Historical Park, National Park Service.



Section through A. B.

Plan of Turning Gates as fitted to the Dry Dock. Navy Yard Boston. Feb. 1840.

Scale of feet



412 Sh. 7

ILLUSTRATION NO. 32

Portrait of Loammi Baldwin (1780-1838) by Chester Harding. Photograph courtesy of M.I.T. Historical Collections.

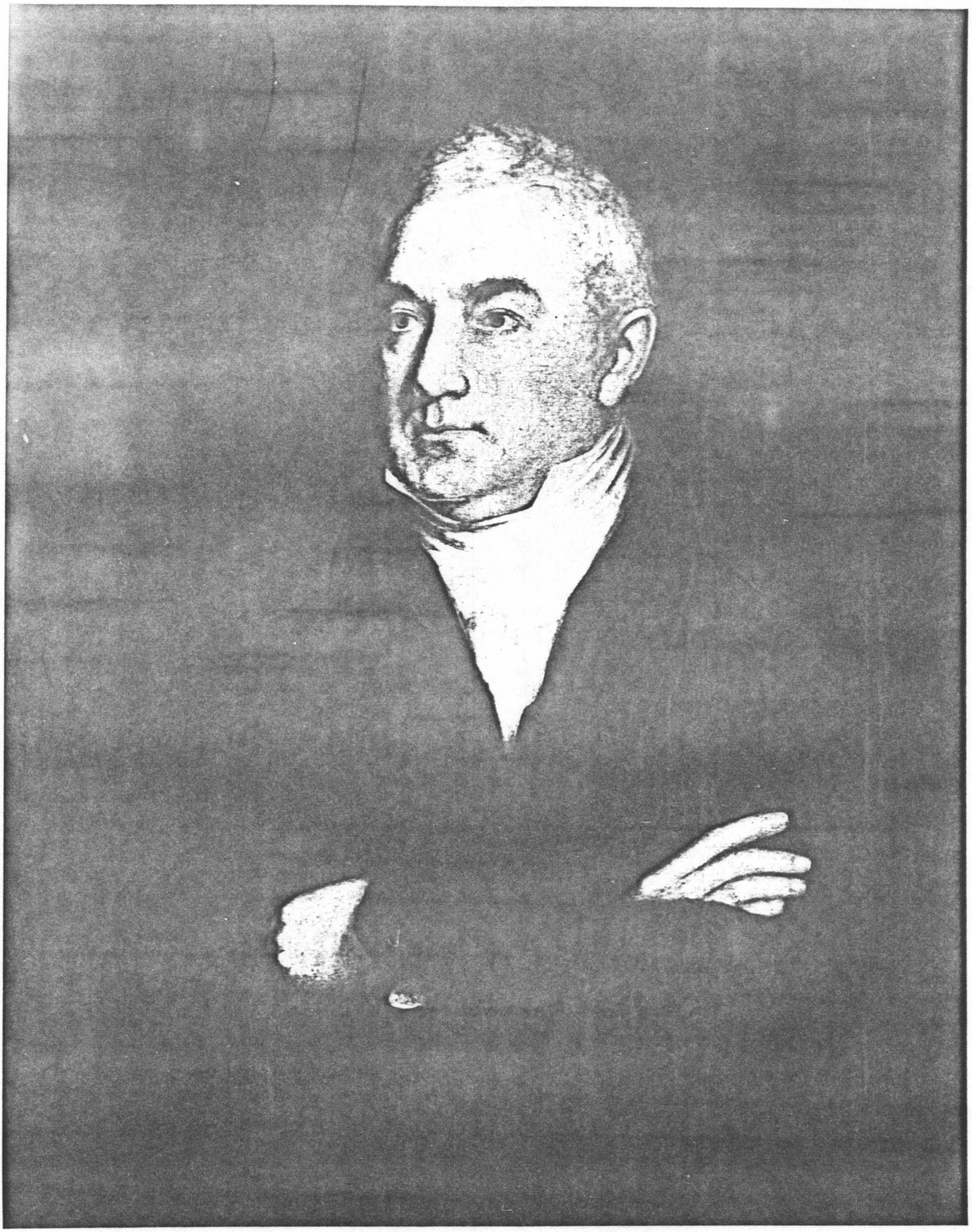


ILLUSTRATION NO. 33

Baldwin Mansion, Woburn, Mass. Loammi Baldwin (1780-1838) spent his childhood in this house that was remodeled in the Federal style by his father in the 1790s. The house has been moved to a site on a short stretch of the original Middlesex Canal. Restoration of the house is planned.

Photograph by the author, 1979.

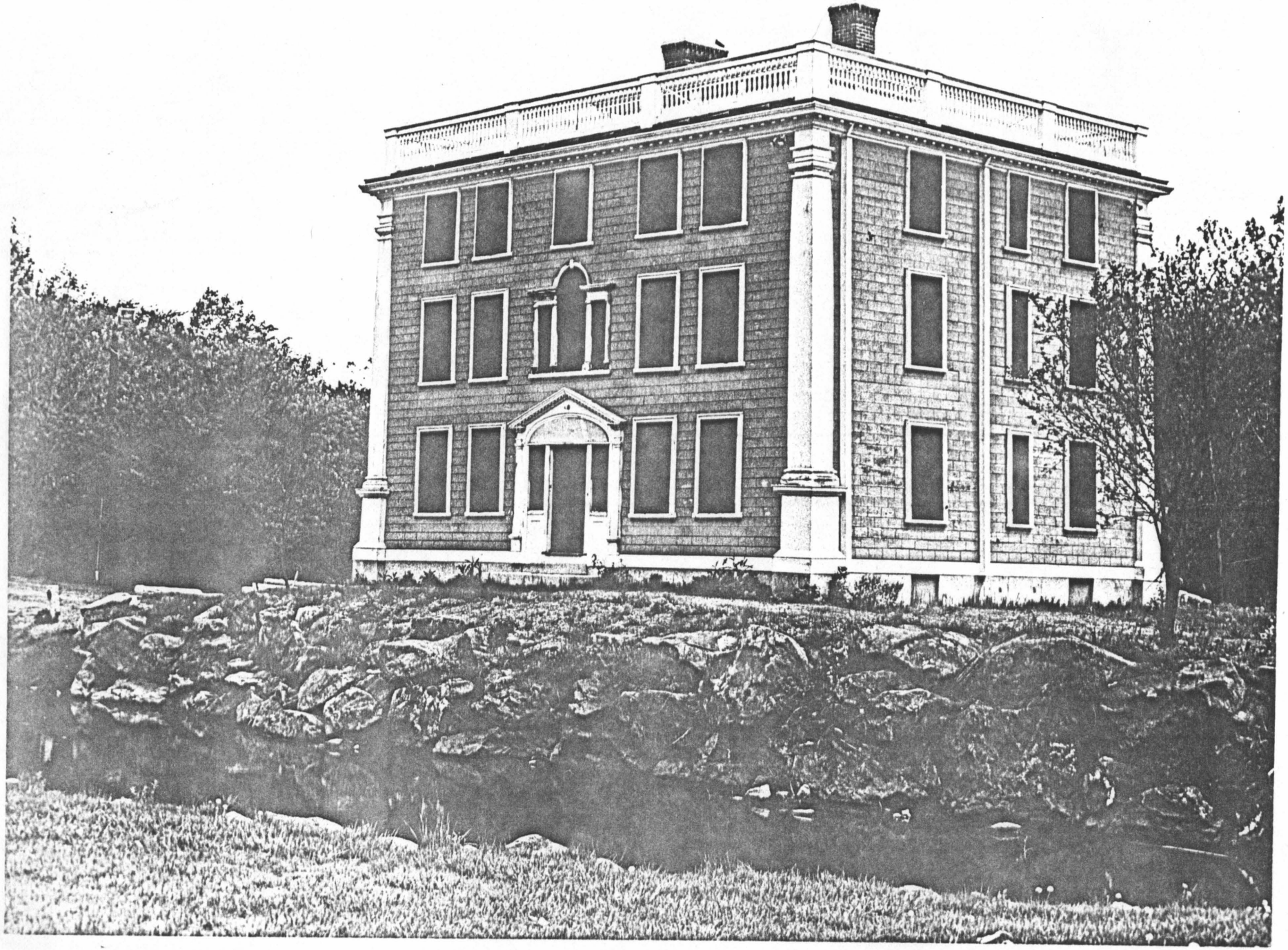


ILLUSTRATION NO. 34

Holworthy Hall, Harvard University, 1812.
Designed by Loammi Baldwin (1780-1838).
Photograph by the author, 1979.

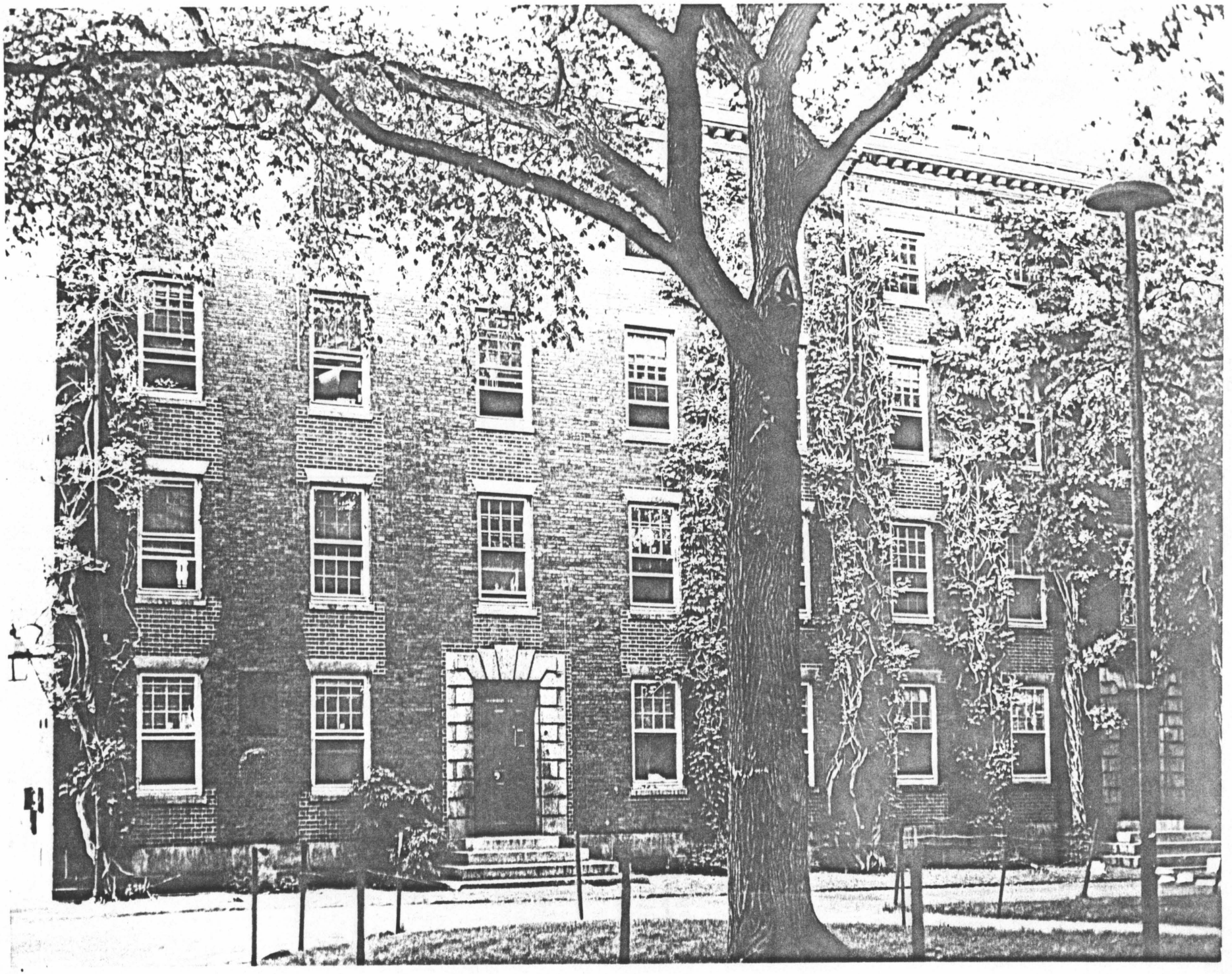


ILLUSTRATION NO. 35

Plan of a Survey & Profile for a Canal
Round the Falls of Ohio, Jan. 24, 1815.
Signed L. Baldwin.

Photograph courtesy of the William L.
Clements Library Division of Maps.

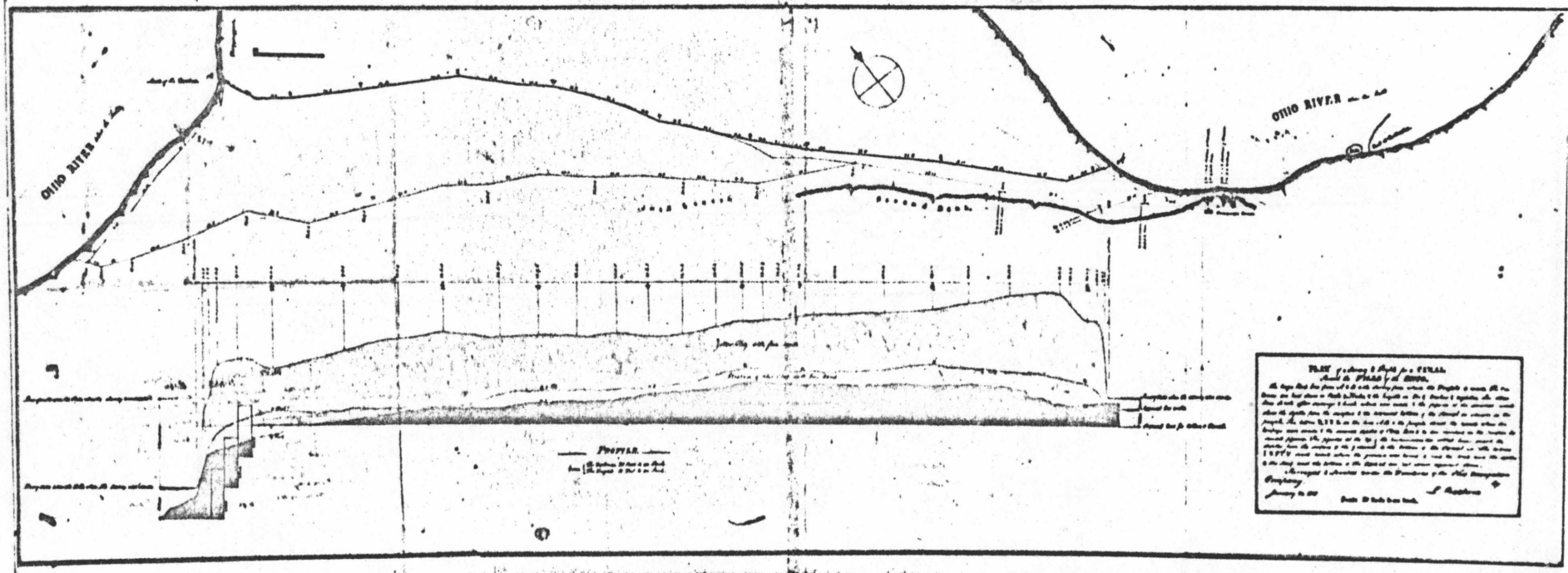

OTTIO RIVER
OTTIO RIVER

ILLUSTRATION NO. 36

Bunker Hill Monument, 1825.
Designed by Loammi Baldwin (1780-1838).
Photograph by the author, 1979.

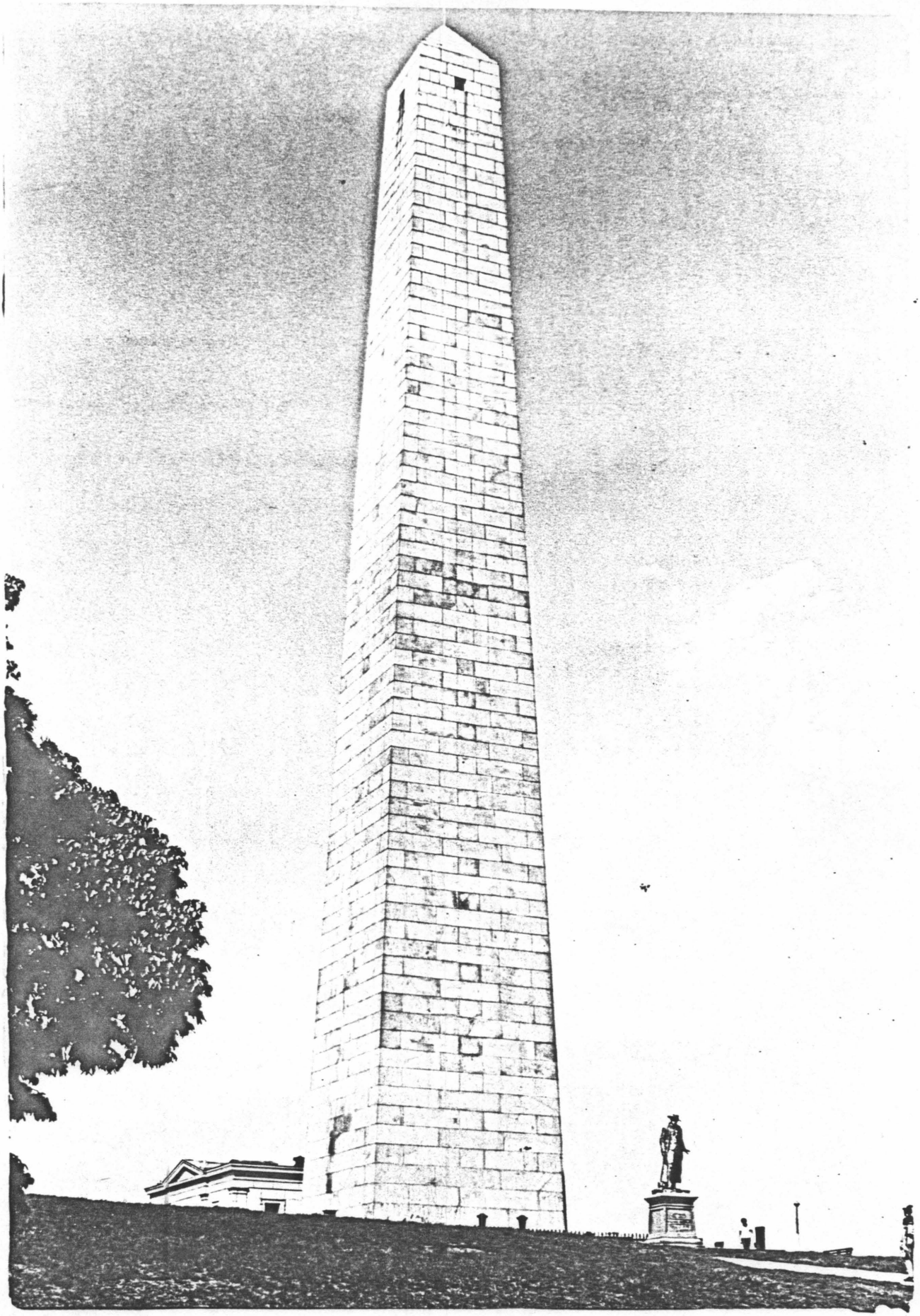


ILLUSTRATION NO. 37

"Plan of the Harbour of Boston from Surveys made under the direction of Commissioners appointed by a Resolve of the Legislature passed March 5, 1835." Signed. L. Baldwin, S. Thayer, James Hayward, January 28, 1837. Surveyed and drawn by B.F. Perham.

Photograph courtesy of the William L. Clements Library, Division of Maps.

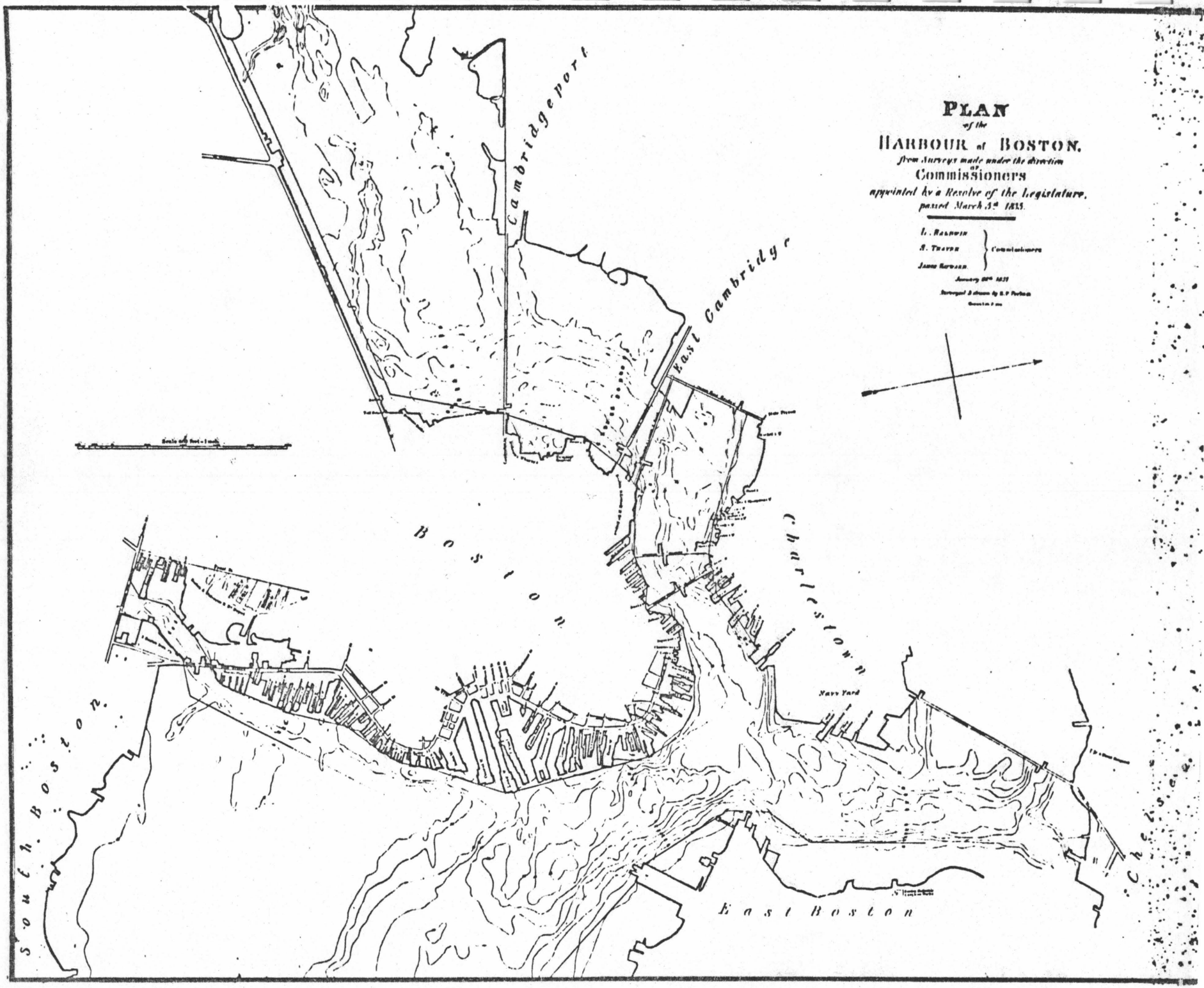
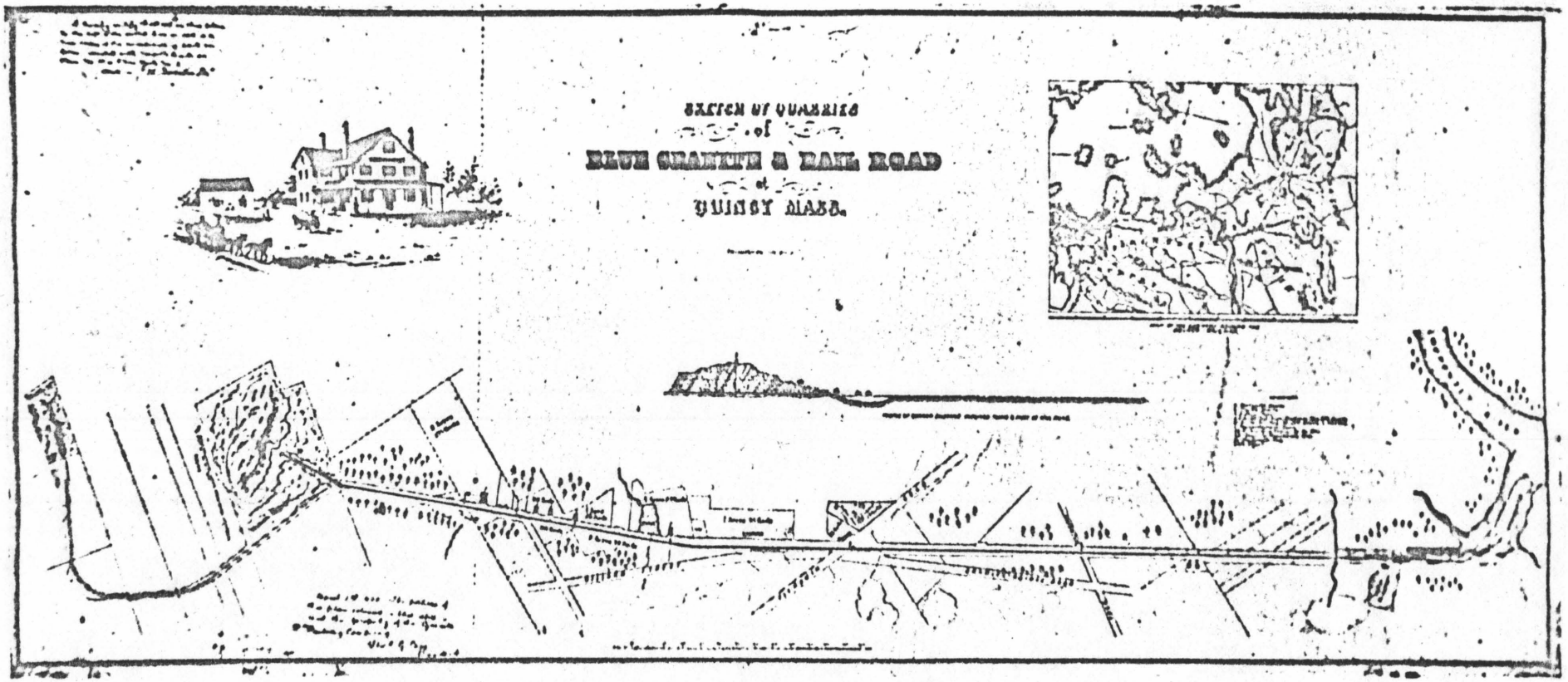

PLAN
of the
HARBOUR of BOSTON.
from Surveys made under the direction
of
Commissioners
appointed by a Resolve of the Legislature,
passed March 3d 1835.
L. Baldwin
S. Thayer
James Barnard
Commissioners
Cambridgeport
East Cambridge
Boston
Charlestown
Navy Yard
South Boston
East Boston

ILLUSTRATION NO. 38

"Sketch of Blue Granite & Railroad at Quincy, Massachusetts."

Photograph courtesy of Quincy Historic Society, Quincy, Massachusetts.



SKETCH OF QUARRIES OF BLUE GRANITE & RAIL ROAD AT QUINCY, MASSACHUSETTS

The insert on left shows the Old Railroad House, while that on right depicts a map of the country around the Quincy Railway. In the upper left [illegible] find the signed statement by the Registrar, J. H. Burdakin, that the property of The Granite Railway Company according to the plan has been recorded with the Norfolk Deeds. In the lower left corner Thomas G. Cary, President of The Granite Railway Company, indicates the property owned by his company. In the shaded part in the center of the picture appears a profile view of the quarry, showing inclined plane and part of railroad

Illustration No. 39

Granite Railway Quarry, West Quincy, Massachusetts

Photograph courtesy of the Parker Collection, Crane Library
Quincy, Massachusetts

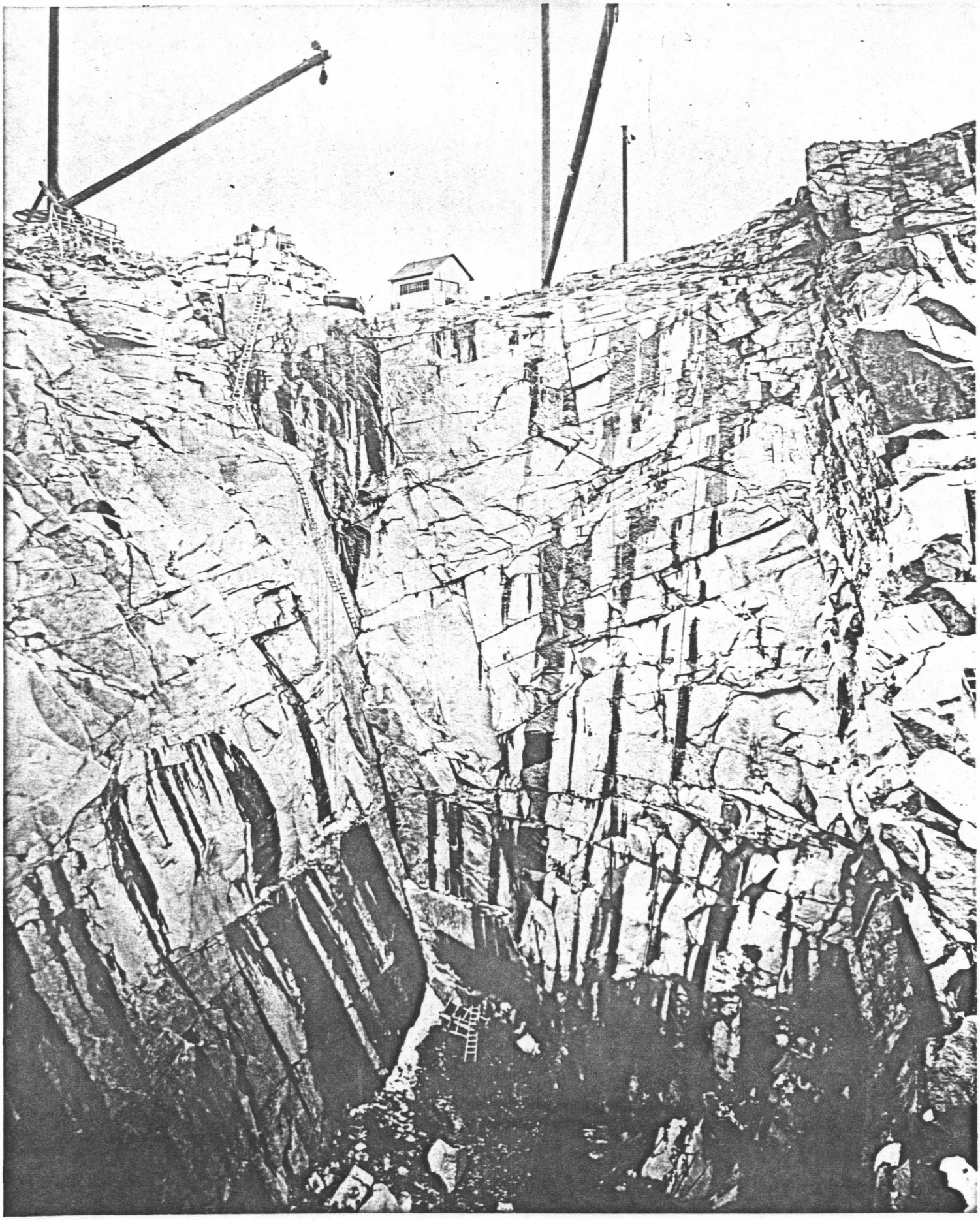


ILLUSTRATION NO. 40

Granite Railway Wharf on the Neponset River, Milton, Massachusetts.

Photograph taken by the author, 1979.

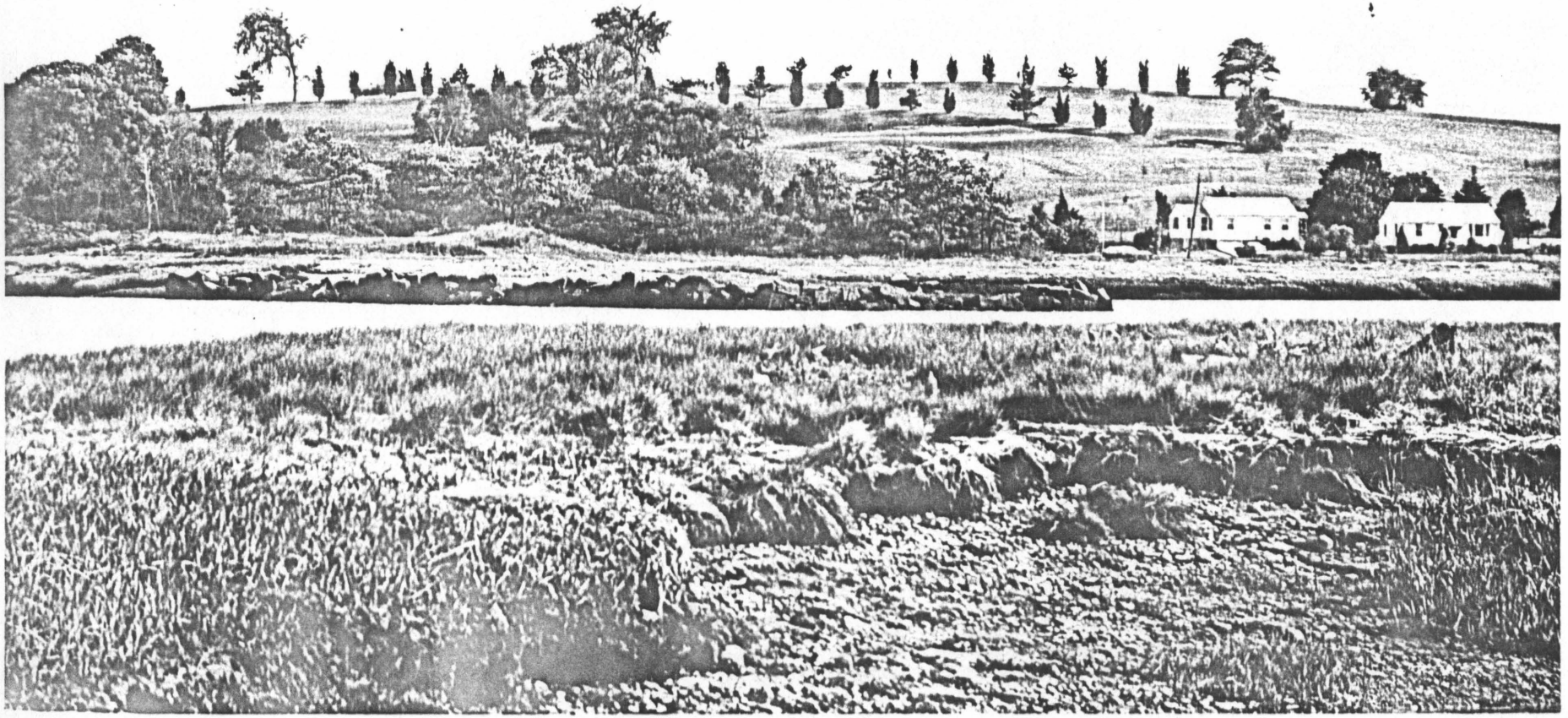


ILLUSTRATION NO. 41

"Stone Sloop," similar to those used to transport granite during the nineteenth century. Watercolor by John F. Leavitt in the collection of the Peabody Museum of Salem. Salem, Massachusetts.

Photograph courtesy of the Peabody Museum of Salem.

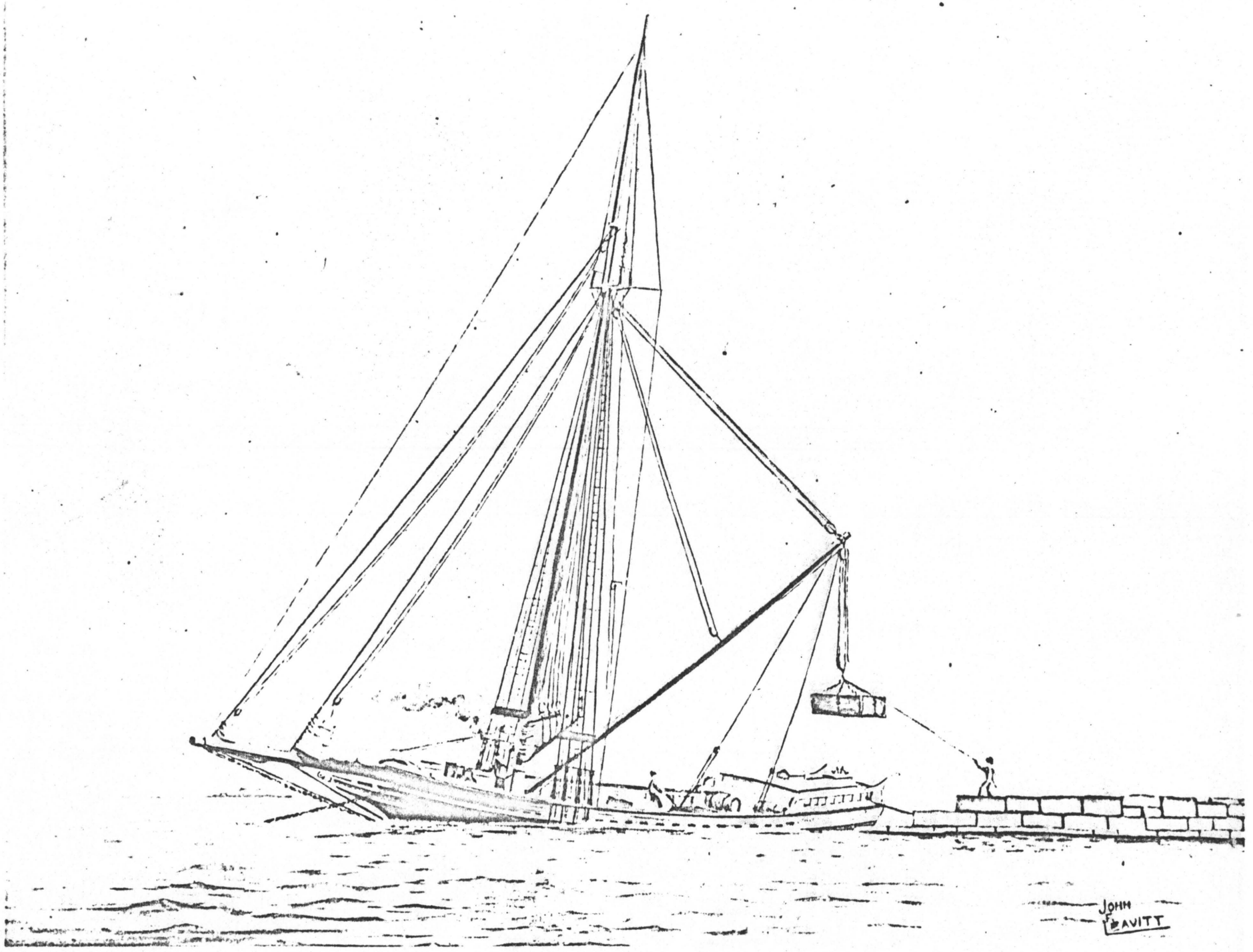

JOHN
FRAVITT

Illustration No. 42

Portrait of Jonathan Newcomb of Quincy, Massachusetts
c. 1820. Note the quarry scene in the background

Photograph courtesy of the Quincy Historic Society
Quincy, Massachusetts



ILLUSTRATION NO. 43

Holmes hoisting Apparatus as illustrated by Solomon Willard in Plans and Sections of the Obelisk on Bunker's Hill. Boston, 1843.

PLATE X.

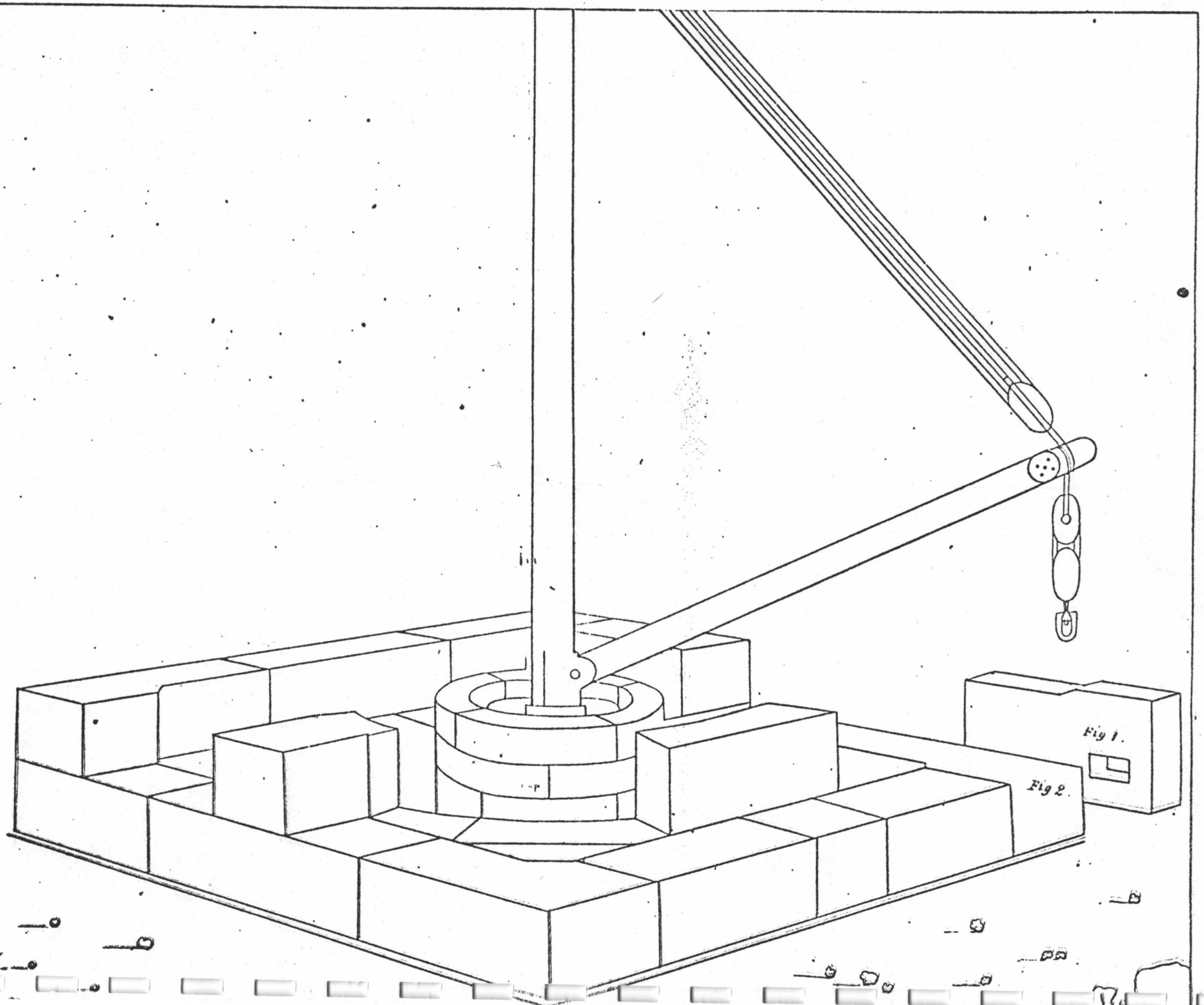


Fig 1.

Fig 2.

ILLUSTRATION NO. 44

Granite Railway Quarry, Quincy, Massachusetts. Late nineteenth century. "Air drilling, after blast. Seam shows stone split with wedges. Row of dots near man's foot are wedges ready to drive. GRanite Railway Quarry."

Photograph courtesy of Parker Collection, Crane Library, Quincy, Massachusetts.



ILLUSTRATION NO. 45

Head of Dry Dock 1, Charlestown Navy Yard, Boston National Historical Park.
The head of the dock was moved 65 feet inland in 1857.

Photograph taken by the author, 1979.

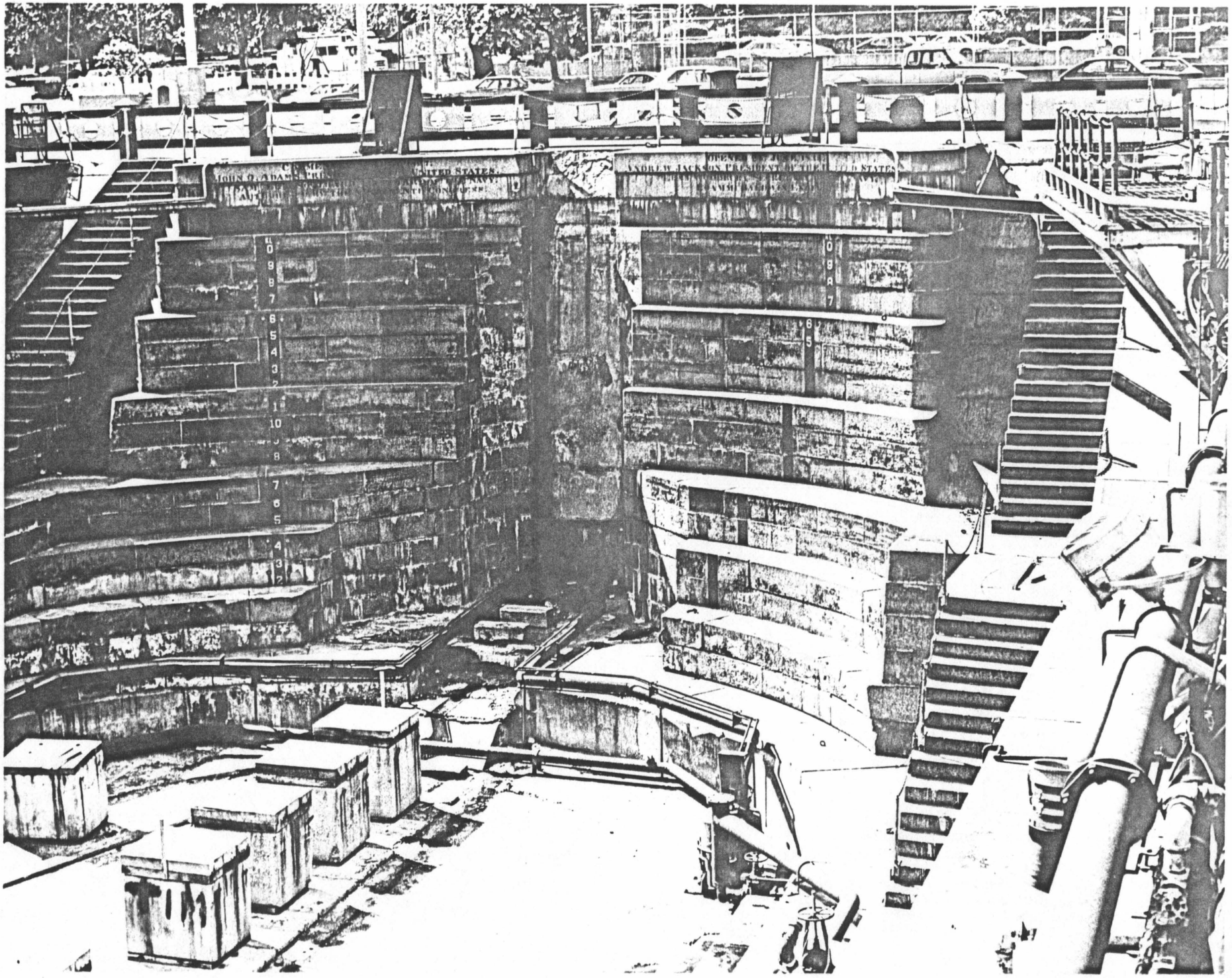

JOHN Q. ADAMS
UNITED STATES
ANDREW JACKSON PRESIDENT OF THE UNITED STATES

ILLUSTRATION NO. 46

Floor of Dry Dock 1, Charlestown Navy Yard, Boston National Historical Park. Showing original line of the head of the dock before extension of 1857.

Photograph taken by the author, 1979.

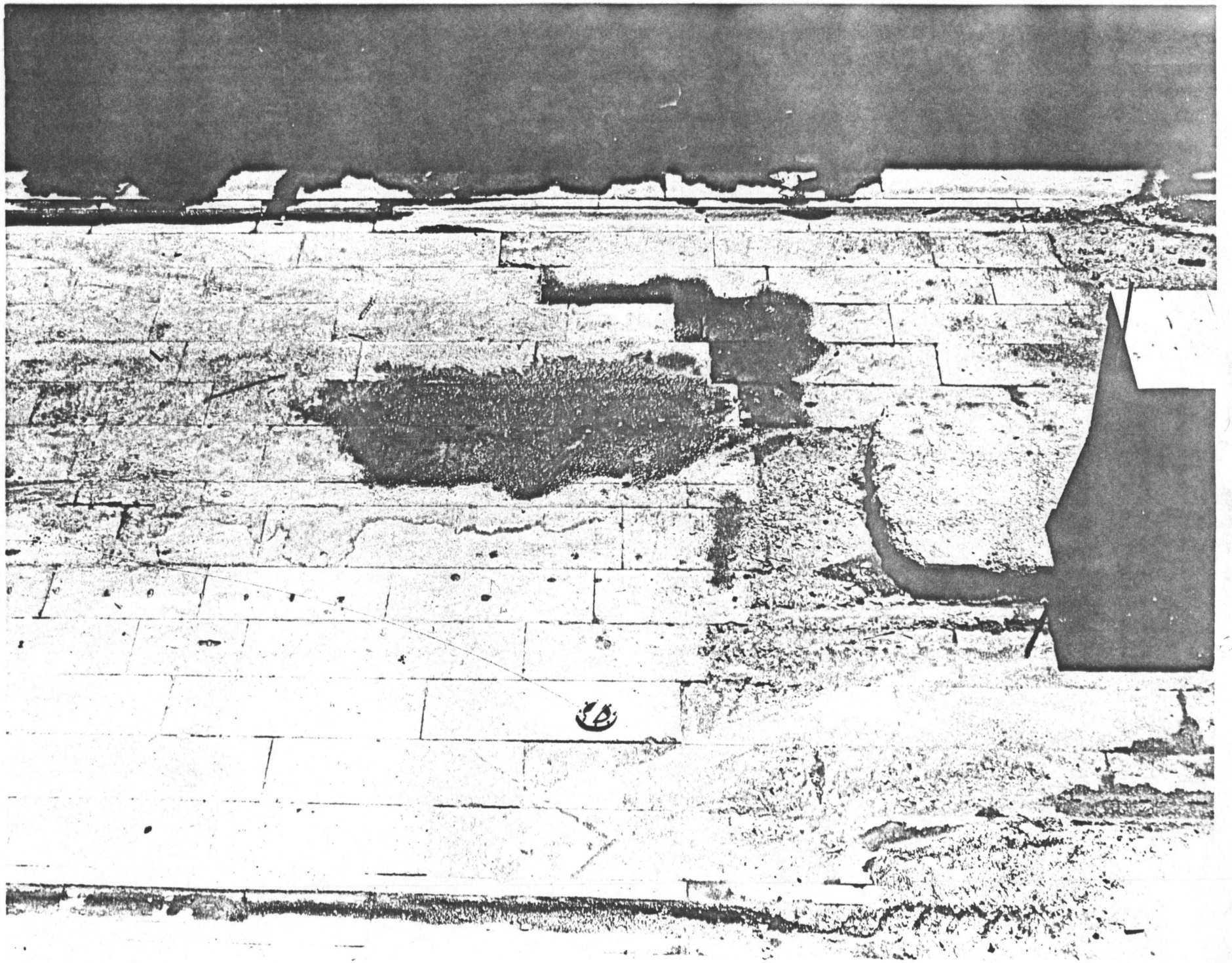


ILLUSTRATION NO. 47

West Wall of Dry Dock 1, Charlestown Navy Yard, Boston National Historical Park. Showing bond of new masonry to old 1857 extension.

Photograph taken by the author, 1979.

