historic structure report
marine railway no. 11
architectural data section
Charlestown Navy Yard

march 1982

BOSTON
CHARLESTOWN NAVY YARD

NATIONAL HISTORICAL PARK / MASSACHUSETTS

HISTORIC STRUCTURE REPORT
MARINE RAILWAY NO. 11
ARCHITECTURAL DATA SECTION
CHARLESTOWN NAVY YARD
BOSTON NATIONAL HISTORICAL PARK
BOSTON, MASSACHUSETTS

By
Mary Jane Brady
and
Crandall Dry Dock Engineers, Inc.

DENVER SERVICE CENTER
BRANCH OF HISTORIC PRESERVATION
MID-ATLANTIC/NORTH ATLANTIC TEAM
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR
DENVER, COLORADO

PREFACE

The condition of Marine Railway No. 11 has rendered any construction or further testing impractical at this time. This report, therefore, is for informational purposes only.

Because no construction or testing is anticipated, compliance with federal historic preservation mandates is not required at this time. Compliance will be required before any development and/or testing, however.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF APPENDICES

I. ADMINISTRATIVE DATA

A. Name and Number of Structure

The Marine Railway, Charlestown Naval Shipyard, Charlestown, Massachusetts is a docking facility 653 feet long, 42 feet wide, with a 352-foot-long cradle.

B. Proposed Use of Structure

Upon rehabilitation, the Marine Railway may be put to use demonstrating the docking and launching of small vessels.

C. Justification for Such Use

The Marine Railway was completed in the spring of 1919, providing additional dry-docking capabilities for the post-World War I Boston Naval Shipyard. It was an expedient and efficient mechanism for hauling small vessels under 2,000 tons for routine maintenance, and it remains an important example of the common docking technique for destroyers and small craft.

Today, a restored and functioning Marine Railway would serve a practical as well as interpretive use. Routine maintenance could be accomplished on small Park Service craft, without the expense of off-site repair.

D. Provisions for Operating Structures

The Marine Railway could function as an additional maintenance facility to Dry Dock 1, while reflecting this historic docking technique used after World War I.

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

The Park has no cooperative agreement on this facility.

II. ARCHITECTURAL DATA

INTRODUCTION

The Marine Railway at the Charlestown Navy Yard, Boston National Historical Park is one of the most significant industrial structures in the yard. Referred to by the Navy as "Marine Railway No. 11," the Marine Railway was used throughout this century in repairs of ships ranging from the Navy Yard tugs to submarines. Marine railways have provided for the haulage of vessels for centuries. They served as an excellent solution to the problem of moving a vessel from water onto dry ground. Marine Railway No. 11 is a sophisticated industrial structure. The principles behind its construction and operation, however, were pressed into use by shipwrights at an early date.

Early methods of making a vessel's hull accessible for maintenance and repairs were limited to a process called careening and the hauling of vessels out of the water manually. Careening was temporary and involved using various methods to tilt the ship to one side, thereby making its hull on the other side rise out of the water. In manually hauling ships onto dry land it was important that the shore was of a moderate slope and had a surface of firm sand or gravel. If a vessel was too heavy to be hauled onto dry land, the tide was used to the greatest possible advantage. The vessel was grounded at high tide and as the tide receded the ship was left dry.[1] This simple method was used by the Egyptians, Phoenicians, and, because it was quite satisfactory for light craft of shallow draft, it was used in small seaports into the twentieth century. By that time a development known as "gridiron" was put into use. Located in a tidal basin, a gridiron was a series of parallel beams or logs laid at regular intervals upon a firm stone foundation. A ship was floated into position over the beams at high tide and was rested upon them by the receding tide.

---

1. Bryson Cunninghan, A Treatise on the Principles and Practice of Dock Engineering, Vol. 1 (London: Chas. Griffin, 1904), p. 462.

All of the early methods of putting a ship up for repairs had limitations. They were useful only in certain localities and most of them relied heavily on the ebb and flow of the tide to position a vessel. In such cases periods of work on the ship's bottom were further restricted to those times when the tide left the hull of the ship exposed.[2] As navies grew, and men depended more and more upon ships for trade and the necessities of life, new methods were developed to facilitate ship repair. The modern marine railway is a vast improvement over methods like careening. As used today the marine railway was developed by the English. In a primitive form, marine railways have been in use for centuries.

The earliest and most primitive examples of a marine railway, referred to by the English as a slipway, appears to have been developed by the Carthaginians. These artificial slipways consisted of smooth timber slides which provided a less frictional surface than the natural shore for hauling up ships.[3] Centuries of development resulted in several types of artificial slipways but all resemble this early design. In the nineteenth and early twentieth centuries the marine railway consisted of long timber ways, carrying iron rails, which were laid at a uniform slope. The ways extended from some point underwater to a point at which the largest vessel to be drawn up was completely free of the tide.[4] A cradle or traveling frame was constructed to travel on the rails. The cradle was moved down the tracks so that the vessel could be floated over it. The ship was then positioned on the cradle which was then drawn up the track by the railway hauling machinery. Cradles generally moved on a series of rollers or wheels, on, in some cases, on well-greased ways.[5]

In 1894 a marine railway was described by Charles Colson in his book Notes on Docks and Dock Construction:

---

2. Ibid., p. 463.
3. Ibid.
4. Ibid.
5. Charles Colson, Notes on Docks and Dock Construction, (London: Longmans Green and Co., 1894), p. 312.

> A slipway consists of a foundation, the nature of which will depend upon the special conditions appertaining to the locality. A platform or roadway, generally of timber, to carry the sliding ways or rails, a carriage or cradle provided with sledgerunners, or with wheels or rollers and with an arrangement of moveable bilge blocks for supporting the vessel; and lastly the hauling machinery whereby the ship is hauled above the water level.[6]

Over fifty years later the terms used to describe a marine railway were strikingly similar as is evidenced by the following quote from F. M. DuPlat Taylor's 1949 text, The Design, Construction and Maintenance of Docks, Wharves and Piers:

> Slipways consist of inclined ways of timber or stone, running up from a sufficient depth of water to the requisite height above high water level, upon which a series of rails is fixed. On these rails suitable carriages run, to support the vessel, and are hauled up or lowered down by means of a winding gear.[7]

Colson also included an excellent description of the operation of a marine railway. It is included here because it is applicable to marine railways in general and so lends further understanding to the operation of Marine Railway No. 11 at the Charlestown Navy Yard.

> The size and general description of the vessel to be taken on having been ascertained, the bilge blocks on the cradle are trimmed to fit the ship as nearly as possible, and the guide rods and other fittings looked to and put in proper position.
>
> The cradle is then run down into the water by its own weight, assisted if necessary by a down-hauling chain worked by an independent apparatus at the top, arranged also for quickly drawing up the empty cradle after launching a vessel.

---

6. Ibid.
7. F. M. DuPlat Taylor, The Design, Construction and Maintenance of Docks, Wharves and Piers, (London: Ernest Benn Ltd., 1928), p. 215.

> The extreme end of the cradle may project thirty to fifty feet over the end of the rails, the main rails being made strong enough for this purpose. The vessel is then floated into position as accurately as possible, being guided by hawsers manipulated from a jetty on the shore, and also by the guides fixed at the front of the cradle, which are drawn up into a vertical position by ropes, afterwards secured to the vessel. The hauling up then commences, the ship continually sitting on the keel blocks placed on the center rib, and being guided at the stern by the after-guides. At the proper time the sliding bilge blocks are drawn in by ropes previously taken up to the jetties, or on board the vessel; the operation then proceeds until finally the ship is drawn out of the water, safely seated on the cradle, and supported uniformly over the whole length of the keel, as well as by the bilge blocks on each side.
>
> In launching the reverse process takes place. The vessel is lowered by the machinery to within a convenient distance of the water; the cradle is then disconnected from the links and, the holding pawls being raised, is left supported entirely on one special pawl, or dagger, at the top. The dagger is then knocked away by a blow from a hammer, and the cradle with its burden runs down the way until it reaches the water, and the vessel floats off.[8]

A. Construction of Marine Railway No. 11

The Marine Railway at the Charlestown Navy Yard is located east of Dry Dock 1 between Piers 2 and 3. Built in 1918, the Marine Railway is of timber and consists of a wooden cradle, 350 feet long by 52 feet wide, and hauling machinery of rollers, hauling chains, sheaves, and an electrically driven winding engine. There are two side tracks and one center track, the side tracks being parallel to and 15 feet away from the center line. The tracks are tied together with vertical and horizontal timber braces. Each track is built of three tiers of timbers with a continuous steel plate rail on top. As originally constructed, the tracks were supported by wooden piles arranged in three longitudinal lines under the tracks. Under the two side tracks the piles were in single rows spaced 4 feet 8 inches on centers over most of the distance with a few at the outer portion spaced 8 feet 6 inches apart. The lower tier of each track bears directly against the piles. Under the center track the

---

8. Colson, Dock Construction, pp. 320-21.

piles were arranged in transverse bents and were capped with 12-inch square timbers upon which the center track was seated. The bents under the center track were spaced 3 feet 6 inches on center except for several at the outer portion which were spaced 6 feet 2-1/2 inches apart.[9]

The Marine Railway track slopes downward toward the outboard end at a rate of 7/8 inch per foot[10] from an elevation of 116.33 at the inshore end to an elevation of 68.79 at the outboard end.[11]

The cradle overhangs the track on both sides and is supported by three longitudinal frames which are spaced transversely to align with the three tracks. The cradle itself is thereby nearly horizontal at all times.[12] The cradle was built in two sections which are joined at amidships. The maximum travel of the cradle along the track is 342 feet.[13]

The process leading to the construction of Marine Railway No. 11 began on February 14, 1918, when the United States Navy put Specification 2843 entitled "Two Marine Railways at the Navy Yards, Charleston, South Carolina and Boston, Massachusetts" out for bid (see Appendix A). Each of the railways was to have a capacity of 2000 gross tons. Each structure was to have wooden floors and blocks.

---

9. Specification 8475, June 18, 1937, Marine Railway Maintenance Files, Maintenance Office, Charlestown Navy Yard, Boston National Historical Park.

10. Ibid.

11. Specification 6277, "Repairs to Marine Railway at Navy Yard Boston," August 1930. Marine Railway Maintenance Files.

12. Ibid., Specification 8475.

13. Ibid., Specification 6277.

A major difference was made in the specification concerning the cradles of the two railways. The cradle for the Charleston railway was to be of structural steel while the one at Boston was to be of timber construction.[14]

Specification 2843 stated that the foundation piles for the Boston railway were to be constructed of North Carolina pine. All timber used in the construction with the exception of the blocking and creosoted material was to be long leaf yellow pine. The keel and bilge blocks that supported a ship being repaired were to be of American rock elm, American white oak, hard maple, or yellow birch.

The ways or tracks of the railway were stringers built up and supported directly on the foundation piles. As described in the specification: "Each stringer shall consist of a base of two pieces, a mid section through which 8 by 12 inch ties pass, and a top piece slightly beveled to receive the roller plate." These pieces were bolted together and attached to the supporting piles with one inch diameter drift bolts.

The proposed construction site for the Boston railway crossed the store foundation walls of an old slip. In Specification 2843 the contractor was directed to remove the top stones of the foundation walls and to lay a bed of concrete on the wall to support the track stringers. The rail plates were 12 inches on the center track and 4 1/2 inches on the side tracks.

The Marine Railway constructed at the Navy Yard in Charleston, South Carolina was protected to a much greater extent than the one built at Boston. As has been noted, the cradle was of structural steel rather than timber. All timber used was creosoted. Construction at Boston was primarily of untreated timber. The structural timbers of the southern railway were also sheathed and protected with ship's felt.

---

14. Ibid., Specification 2843, "Two Marine Railways at the Navy Yards, Charleston, S.C., and Boston, Mass.," March 18, 1918.

Originally Marine Railway No. 11 at Boston was given no such protection. Presumably these differences in the two railways were made to protect the marine railway at Charleston from marine borers which would have been more active in the warmer waters of South Carolina.

The rollers that carried the cradle of the railway at Boston were cast iron, 4 inches in diameter and 12-1/2 inches in length for the center track, and 3-3/4 inches in diameter and 5 inches in length for the side tracks. The cradle deck was made up of 3-inch-long leaf yellow pine planks. Plank walkways of the same wood were installed on each side of the cradle. The chains used for hauling the cradle were made of reworked iron and the hand winches used to move the bilge blocks were cast iron.

The motor that was installed to operate the hoisting machinery was specified as a polarwound, 3-phase, 60-cycle, 220-volt induction motor of not less than 200-horsepower capacity. The hoisting machinery was placed on a foundation of concrete on piling. Originally, Specification 2843 called for a one-story building to house the machinery. Apparently this part of the specification was changed when the contract was awarded. The machinery was placed, instead, in the southeast corner of Building 24 where it has been housed up to the present day.[15]

The contract for the construction of the Marine Railway at Boston was awarded to the Crandall Engineering Company. Today the company is located at Dedham, Massachusetts under the name Crandall Dry Dock Engineers, Inc. Marine Railway No. 11 was designed by James L. Crandall and was built by the Crandall Construction Company.[16] Construction began in the spring of 1918, and on June 2, 1919, the ship

---

15. "Location of Hoisting Machinery in S.E. Corner of Building No. 24," July 1918, Marine Railway Drawing, Maintenance Office.

16. Crandall Dry Dock Engineers, Inc., "Report of Condition, 2,000 Ton Railway Dry Dock No. 106, Boston Naval Shipyard, December 31, 1962," Marine Railway Maintenance Files.

U.S.C.G. Ossippee was used in the first of the railway. On June 10, 1919, the U.S.S. Grebe and the U.S.S. Acushnet were both hauled up to test the capacity of each half of the cradle.[17] The joint at the cradle's midpoint allowed one ship to be hauled to the inshore end of the railway at which time the second section of the cradle was lowered again to take on another vessel (see Illustrations 5, 6, and 7). All of these tests were successful.

The maximum dimensions of ships to be docked in the Marine Railway, as originally constructed were as follows:

USING THE ENTIRE CABLE

Maximum Length	330 feet
Maximum Breadth	40 feet
Maximum Draft Forward	13 feet 5-1/2 inches
Maximum Draft Aft	16 feet 8-1/2 inches
Maximum Draft Mean	15 feet 1 inch
Maximum Displacement - 2000 Tons (capacity of railway)	

USING INBOARD SECTION OF CRADLE

Maximum Length	170 feet
Maximum Draft Forward	13 feet 5-1/2 inches
Maximum Aft	14 feet 11-1/2 inches
Maximum Draft Mean	14 feet 2-1/2 inches[18]

B. Maintenance of Marine Railway No. 11, 1919-73

After being tested successfully during the spring of 1919, the Marine Railway was operated without incident for several years. An accident in 1923, however, did leave the railway in need of extensive repairs. The accident and resulting damage were described in a "Report of Repairs to Runway and Hauling Parts" dated September 10, 1923.

---

17. Crandall Construction Company, "Marine Railway Contract 2843," Booklet of Job Photographs, Charlestown Navy Yard Archives.

18. "Approximate Limiting Dimensions of Ship for Docking," 1933, Marine Railway Drawing, Maintenance Office.

On March 22, 1923 the "Putman" was being hauled onto the Marine Railway. It had been reported that the hauling chains, as they left the chain wheels, were so slack that they rested on the ground in the pit in front of the machinery house. Owing to the fact that the chain did not haul itself readily away from the chain wheel 4, it accumulated at the wheel breaking one of the links of the slack chain at the wheel. Hauling was stopped, a temporary link was wired in and the hauling continued, special care being exercised that the chains did not again jam.

On March 28 the "Putman" was hauled off the Marine Railway. While the cradle was at its outboard position, preparations were made to take off the hauling chains for testing. To do this the chains on wheels 1 and 4 were removed and lashed to concrete struts at the head of the runways. The cradle was pulled up part way by the aid of chain wheels 2 and 3, the equalizer acting as single sheave blocks. The shackles on the hauling chains, which normally remain at the sheaves now travelled toward the chain wheels. Owing to their position on edge at the sheaves, they now approached the chain wheels in the same position. The shackle passed over chain wheel 2 all right and about six feet ahead of the other shackle. The second shackle on reaching chain wheel 3, did not pass over the wheel but slid off onto the shaft of the chain wheels taking the chains with it.

With the chains off of hauling wheel 3, the strain was released from the equalizer A, placing it all on equalizer B, which after being hauled forward to its limits in the slides was brought up with a jerk breaking the lashing on that side. This allowed the cradle to run down the runways. Now it seems that sometime during this travel that the chain, running freely over the chain wheel shaft, was jammed causing the equalizer A to be pulled forward to the extreme limits of its slides bringing up with a jerk that tore away the remaining lashing and allowing [sic] the cradle to travel unrestrained down the runway. When the floor of the cradle struck the water it lifted itself from the runways and in settling down did not return to its position on the track. The outer section of the cradle had a decided wind towards the west or Pier 2. It is probable that the equalizer A was pulled out of its slide and was hanging unsupported.[19]

Extensive repairs were made to the Marine Railway following this accident in order to return it to working order.

---

19. "Sketches of Hauling Gear to Accompany Report of Repairs to Runway and Hauling Parts, Sept. 10, 1923," Marine Railway Drawing, Maintenance Office.

In September 1930 an underwater inspection was made of the track bracing.[20] As a result necessary repairs were made to cradle tie rods, new wooden liners were provided for the steel frames holding the rollers, the track bracing was repaired, and replacement timbers were inserted where there was extensive damage due to limnoria or other marine borer activity. The repairs to the track bracing were directed as follows:

> The existing longitudinal braces, both upper and lower sets, shall be left in place and the new longitudinal braces shall be installed immediately below them on all of the ____. The horizontal cross braces below the lower longitudinals shall be removed and new cross braces shall be installed below the new lower longitudinals. The diagonal braces, both longitudinal and transverse shall be removed and new braces shall be installed in lieu thereof. All cross braces and diagonal braces shall be removed one at a time and the new substitute brace shall be installed immediately after the old one has been removed.[21]

All of the repairs were made with creosoted yellow pine. Gaps in timbers due to limnoria activity were filled with a special cement mortar. The damaged timbers were then sheathed with 1-1/2 inch boards.[22] The repairs were made under contract NOy-873 by Crandall Engineers, Inc. When these repairs were made an inspection was made of the underwater portions of the cradle. It was declared to be in good condition with a minimal amount of worm damage. The engineers suggested that the cradle be given a protective layer of ship's felt covered with creosoted boards. As stated in a report made to the U.S. Navy, these steps "would give the cradle almost complete protection for a long period of years, but if this work is delayed for long the worms will continue their attack on the cradle causing serious damage and expensive building and repairs."[23]

---

20. Specification 6277, August 1930, Contract NOy-873, Marine Railway Maintenance Files.

21. Ibid.

22. Ibid.

23. Crandall Engineering Company, Report on Marine Railway, October 28, 1930. Marine Railway Maintenance Files.

Crandall Dry Dock Engineers later enumerated repairs made to the Marine Railway in 1931 as follows:

1) Cradle rods tightened.
2) Roller frames renewed with creosoted yellow pine.
3) Track braces renewed with creosoted yellow pine.
4) Shims on piles replaced where missing.
5) One hundred seventy five pieces of new creosoted bracing on the piles under the outer section of the track.
6) Top tier of center track protected with cement.
7) Twenty-four piles cut where eaten by worms, nineteen 12-inch caps placed between cut-off and track structure.
8) Three guide pieces in the chain slides replaced.24

In this same year the granite load bearing sea walls adjacent to the Marine Railway were replaced with reinforced concrete walls. The concrete used in the construction of the retaining walls was mixed with a ratio of 1:2-1/2:5.[25]

In April 1934 the U.S. Navy advertised for bids for additional repairs to Marine Railway No. 11. The repairs were authorized by the National Industrial Recovery Act of June 16, 1933. A second accident had occurred on the railway. The hauling chains had broken and the cradle while resting on the rails was 80 feet beyond the outboard end of the track.[26] The repairs called for under the Navy's specification included, "hauling the cradle back up the track if so required . . . furnishing of new cast steel main hauling chains and main equalizer chain . . . installation of new main chains and of backing chains."[27] This contract was also awarded to the Crandall Company. The agreement was signed on April 20, 1934, at an estimated cost of $17,700 for the repairs.

---

25. "Marine Railway Retaining Walls," October 2, 1931. Marine Railway Drawing, Maintenance Office.

26. Specification 7666 "Repairs to Marine Railway, April, 1934," Marine Railway Maintenance Office.

Crandall Dry Dock Engineers later enumerated repairs made to the Marine Railway in 1931 as follows:

1) Cradle rods tightened.
2) Roller frames renewed with creosoted yellow pine.
3) Track braces renewed with creosoted yellow pine.
4) Shims on piles replaced where missing.
5) One hundred seventy five pieces of new creosoted bracing on the piles under the outer section of the track.
6) Top tier of center track protected with cement.
7) Twenty-four piles cut where eaten by worms, nineteen 12-inch caps placed between cut-off and track structure.
8) Three guide pieces in the chain slides replaced.24

In this same year the granite load bearing sea walls adjacent to the Marine Railway were replaced with reinforced concrete walls. The concrete used in the construction of the retaining walls was mixed with a ratio of 1:2-1/2:5.[25]

In April 1934 the U.S. Navy advertised for bids for additional repairs to Marine Railway No. 11. The repairs were authorized by the National Industrial Recovery Act of June 16, 1933. A second accident had occurred on the railway. The hauling chains had broken and the cradle while resting on the rails was 80 feet beyond the outboard end of the track.[26] The repairs called for under the Navy's specification included, "hauling the cradle back up the track if so required . . . furnishing of new cast steel main hauling chains and main equalizer chain . . . installation of new main chains and of backing chains."[27] This contract was also awarded to the Crandall Company. The agreement was signed on April 20, 1934, at an estimated cost of $17,700 for the repairs.

---

25. "Marine Railway Retaining Walls," October 2, 1931. Marine Railway Drawing, Maintenance Office.

26. Specification 7666 "Repairs to Marine Railway, April, 1934," Marine Railway Maintenance Office.

Under the contract with Crandall the hauling chains were entirely replaced. The replacement chains were cast steel marine railway chains unlike the originals which were wrought iron. The change from wrought iron to cast steel increased the hauling strength of the chain thirty-six percent. The four sprocket wheels were not replaced, however, and as late as 1962, Crandall noted that the original carbon steel sprockets were still in use.[28]

In 1934 alterations were also made to the fantail or outboard end of the railway cradle. The changes consisted of lowering a section of the deck, replacing some of the decking with new 4-inch planks and strengthening the new work with additional diagonal bracing.[29]

Inspections of the Marine Railway, both above and below water, were undertaken regularly. One such inspection was made in June 1937 of the underwater portions of the structure. At that time the cradle runners had been worn down 1/8 of an inch from its original size. The backhaul sheaves, attached to the track, and the main hauling sheaves, attached to the underside of the cradle, as well as the eyebars that fastened the two halves of the cradle together were all found to be in satisfactory condition.[30]

Between 1936 and 1938 a proposal was made to extend the Marine Railway. Major repairs to the railway were planned and, in order for the structure to accommodate ships of the Phelps class, an extension of 20 feet was also proposed. Before such an extension was approved, however, plans were made to extend Dry Dock 1 at the Navy Yard. As the Dry Dock would then be able to handle the larger ships, the plans

---

28. Crandall Dry Dock Engineers, "Report of Condition, 2,000 Ton Railway Dry Dock No. 106, Boston Naval Shipyard, December 31, 1962," Marine Railway Office.

29. "Alteration at Fantail," May 28, 1934, Marine Railway Drawing, Maintenance Office.

30. Specification 8475, "Underwater Inspection, Marine Railway at the Navy Yard, Boston, MA," June 18, 1937. Marine Railway Maintenance Files.

for the extension of the railway were shelved. Projected work on the Marine Railway was therefore limited to $40,000 worth of repairs that would keep it operable up to the original capacity of 2,000 tons.[31] In 1951 an estimate was drawn up to extend the railway 50 feet, but this proposal was also shelved before any changes were made to the Marine Railway.[32]

A large scale reconstruction of the Marine Railway was undertaken in 1940. The side frames of the cradle were reinforced as were the center supports.[33] Beginning in June 1941 the cradle, track, and supporting pile structures were completely overhauled, repaired, or rebuilt. The capacity of the track and cradle was increased from 2,000 to 3,000 long tons. No changes were made to the hauling machinery, however, so the overall capacity of the railway remained at 2,000 tons.[34]

The reconstruction of the Marine Railway was done by Crandall under contract NOy-4814. As described in a Crandall report the work done under this contract included a complete rebuilding of the timber track structure. Rail plates, sheathing, and chain gears were all replaced. The side track piling, originally a single row of piles, was replaced by two pile bents. The original piles were cut off at mud line or pulled out. Some of the old rail plates were used to reinforce the bottom chord of cradle runners and the cradle runners were reinforced as Warren Trusses.[35] The track timbers were sheathed with one-inch-thick

---

31. "Extension of Marine Railway," September 21, 1936. Marine Railway Maintenance Files.

32. Maintenance Records, October 8, 1951. Marine Railway Maintenance Files.

33. "Reconstruction of Boston Ways," 1940. Marine Railway Drawing, Maintenance Office.

34. Maintenance Records, March 7, 1945. Marine Railway Maintenance Files.

35. Crandall Engineering Company, "Report of Condition of 2,000 Ton Railway Dry Dock No. 106," December 31, 1962. Marine Railway Maintenance Files.

boards of "sound Southeast Norway Pine creosoted to refusal" laid over ship's felt. The rest of the timber used in the work was "prime, structural, Long Leaf Yellow Pine" except for the deck reinforcing which was done with select structural fir. Under the contract Crandall also overhauled the backing chain equalizing assemblies, renewed the turnbuckle diagonal tie-rods for the docking platform, and replaced the original stone in the ballast lockers.[36] After making these extensive repairs Crandall estimated that it would cost $45,000 to replace the hauling machinery so that it could haul the additional 1,000 ton capacity of the cradle.[37]

The reconstruction and repairs were completed to allow the operation of the railway by May 1934. The cost of rebuilding the Marine Railway was $373,672.[38]

During the 1930s and 1940s the Navy apparently had difficulties keeping the Marine Railway free of ice during the winter months. A photograph dated February 5, 1935 shows the railway cradle partially submerged and frozen in the ice.[39] To solve the problem and keep the railway in operating condition a salt water, hot water system for thawing the Marine Railway was installed. A storage tank was placed on the eastern side of the railway and the system was tied into the Navy Yard's existing steam lines.[40]

---

36. Crandall Engineering Company, "Repairs to Cradle as Constructed Under Contract NOy-4814," May 9, 1942. Marine Railway Maintenance Files.

37. Maintenance Records, March 6, 1943. Marine Railway Maintenance Files.

38. "High Spots in the History of the Industrial Department of the Boston Navy Yard from 1 January 1939 to 30 June 1945," July 24, 1945, typescript, Constitution Museum, Charlestown Navy Yard.

39. Photograph of Marine Railway, February 5, 1935. Charlestown Navy Yard Archives, Charlestown Navy Yard.

40. "Marine Railway No. 11, Ice Melting System, 1943," Marine Railway Drawing, Maintenance Office.

For a brief period after World War II the capacity of Marine Railway No. 11 was limited to about 1,700 long tons. Repairs made in 1948 returned the railway to its original capacity of 2,000 tons.[41]

Routine inspection and maintenance continued on the railway. In December 1951 the chain wheels were built up by welding to prolong their useful life.[42]

In December 1952 an accidental seizure of the emergency brake of the hauling machine caused line shaft bearings and three spokes of the main gear to break. The bearings were subsequently replaced and the main gear body was reinforced with steel plates so that it was stronger than the original iron gear. A new hydraulically released emergency brake and an electric limit switch was provided on the stop pawl to prevent operation in reverse.[43] Crandall made the repairs and repositioned the cradle which had derailed. The cradle repairs cost $9,000 while the machinery repairs came to a total of $3,500. The work was done according to Specification 38496 under Contract NOy-77999 dated March 25, 1953.[44]

In the autumn of 1953 a survey was made of the track elevation of the Marine Railway. Afterwards an urgent request was made for $5,000 to regrade the track. The work was covered by Specification 40215 of February 16, 1954, and the contract was awarded to the Crandall Engineering Company. As stated in the specification the work done consisted of "raising the sunken section [109 feet in length] of the center track so as to provide a constant track gradient." To accomplish this

---

41. Maintenance Records, June 22, 1948. Marine Railway Maintenance Files.

42. Crandall Dry Dock Engineers, "Report of Condition of Marine Railway No. 106 . . . December 31, 1962."

43. Ibid.

44. Maintenance Records, December 23, 1953. Marine Railway Maintenance Records, Maintenance Office.

task a diver was to "wedge up the center way between pile caps and the center of the track." Once the track was raised to the correct grade the space between the pile cap and the track beam was to be measured and a shim was to be inserted to hold the track beam at the corrected elevation.[45]

A series of improvements, some of them major, were made to Marine Railway No. 11 in 1954. These included the installation of "a manually operated hand brake assembly to operate independently of the existing thruster type automatic brake motor shaft." This brake was to be essentially the same as that used before the automatic brake was installed.[46]

The railway roller system was also completely replaced in 1954. The new rollers and roller frames were steel. As described by Crandall, the firm that handled the replacement, "The center rollers were made special to assure that the side roller flanges would not bear against the rail or shoe plates and that the center rollers, more stable, would serve to hold the cradle on the track.[47]

In 1956 repairs to the railway included repairs to certain portions of the existing timber decking, the replacement of the stone ballast, repairs to ballast lockers, renailing and resheathing certain portions of the runners and bracing, and the flotation and renewal of the bow section of the cradle so that the aft section could be repaired in the dry. Cradle sheathing was replaced where necessary. Once again, a layer of "Irish Ship's Felt" was placed underneath the sheathing. Appropriations for these repairs was $35,350.[48]

---

45. Specification 40215, February 16, 1954. Marine Railway Maintenance Files.

46. Contract 17/54 1954. Marine Railway Maintenance Files, Maintenance Office.

47. Crandall Dry Dock Engineers, "Report of Condition of Marine Railway No. 106 . . . December 31, 1962."

48. Specification 48667, February 14, 1956. Marine Railway Maintenance Files, Maintenance Office.

Under a second specification and contract put out in 1956 the railway's backing chains were replaced and the underwater sheave case was reconditioned. Metal chain slides were installed in all crossties to replace worn out wooden slides, whose collection of abrasive sand had caused extensive wear to the hauling chains. The cost of this work was $43,300.[49]

In November 1959 Crandall Engineering made a thorough inspection of the Marine Railway and declared that it was safe to operate it up to its original capacity.[50] Earlier that year the Navy had stated that the railway was more than adequate "for the docking of tugs and yard craft for which it is now used."[51] The Marine Railway was also used to dock submarines and destroyers during this period. This is evidenced by the fact that alterations were made to the structure on several occasions so that it could accommodate vessels with sonar domes.[52] Earlier such vessels could not be docked in the railway because it lacked a sonar pit or the blocking necessary to clear the dome.

Crandall Engineering inspected the railway in 1961 and assessed the structural conditions in a report. The cradle and undercarriage above low tide were sound. The bilge block and winches were in good condition requiring only lubrication. The slide irons of the bilge blocks were badly rusted while the blocking itself was in fair condition. The underwater sheaves, roller system, rails and shoe plates were all in good condition. The hauling chains, now twenty-eight years old, were in good condition for 210 feet. The next 350 feet fit poorly. Crandall suggested replacing

---

49. Specification 5919/56, "Reconditioning of Marine Railway Tracks and Chains," September 25, 1956. Also Contract NOy-91037. Marine Railway Maintenance Files, Maintenance Office.

50. Maintenance Records, November 2, 1959, Marine Railway Maintenance Files, Maintenance Office.

51. Completed Design Project 4-1957, Maintenance Records, Marine Railway Maintenance Files, Maintenance Office.

52. Ibid. Also "Alteration to Provide Clearance for Dt Sonar Domes," March 5, 1963, Marine Railway Drawing, Maintenance Office.

the sections that would be required to take a full load. The backing chains were in good condition. At the head of the track, however, the return chains were cutting into the wooden troughs and Crandall suggested that the troughs be replaced with cast steel. The chain wheels, made in 1918 to carry wrought iron chains, had been badly worn by the replacement cast steel chains. The engineers suggested the purchase of four new cast steel sprocket wheels and new cast steel chains where maximum loading capacity was necessary.[53]

The chain wheels were replaced with East Steel chain wheels made according to Crandall's pattern C135 although the work was not completed until 1968.[54] A crack in the main centerline sheave was the cause for its replacement in 1965.[55] In 1965 a holding device was also added to the Marine Railway "to infallible anchor" it and to prevent the cradle from rolling down the track.[56]

While inspecting Marine Railway No. 11 in July 1965 the Navy recorded limitations in the operating capacity of the structure. The Marine Railway was not to be used when other docking facilities were available. As stated in Navy maintenance records, "In an extreme emergency, when no other facilities can be made available, one 2000 ton ship may be lifted before repairs are effected. . . ." The author continued saying that replacement of the bull gears and repairs to the railway substructure were routine repairs that would be accomplished under contract. An economic study was underway, however, to determine the feasibility of replacing the hauling chains at a cost of $26,000. The

---

53. Crandall Dry Dock Engineers, "Report of Condition of Marine Railway No. 106 . . . December 31, 1962."

54. Specification 74999, July 1963. Marine Railway Maintenance Files, Maintenance Office.

55. Maintenance Records, March 24, 1965. Marine Railway Maintenance Files, Maintenance Office.

56. "Replacement of Chain Wheels & Repairs," February 2, 1966. Marine Railway Drawing, Also Specification 74999/66, March 22, 1966, Marine Railway Maintenance Files, Maintenance Office.

chains were showing considerable wear and, pending their replacement, extreme care was to be taken in docking ships.[57]

Apparently, the hauling chains were not replaced between 1965 and 1973 when the Boston Naval Shipyard was disestablished. Crandall Dry Dock Engineers, Inc. has no record of new chains being installed and a cursory inspection of the Marine Railway by the Crandall firm in 1978 indicated that no such replacement had been made within the past fifteen years.[58]

In 1966 most of the eye bars connecting the inboard and outboard sections of the railway cradle were replaced. This reduced the possibility of accidents on the Marine Railway.

In 1967 temporary repairs to the Marine Railway included covering all holes in the structure with plywood pending a complete structural job.[59] In 1968 Crandall Dry Dock Engineers, Inc. were hired to make a complete underwater and above water examination of the Marine Railway and to recommend repairs. The report following this inspection suggests the replacement of the existing timber cradle with one of steel if a major rebuilding of the structure was contemplated. As stated by Crandall,

> This would only be warrented if major reconstruction is contemplated for another 30 years of dock operation. The condition of rail places and rollers is such that the rolling friction is building up beyond the design values and may cause damage to the sheathing and potential derailment. We would estimate at this time that within five years this dock must either be overhauled completely or be put out of service.[60]

---

57. Maintenance Records, July 1965, Marine Railway Maintenance Files, Maintenance Office.

58. Telephone interview with Mr. Robert Nelson of Crandall Dry Dock Engineers, August 10, 1979.

59. Maintenance Records, November 1, 1967. Marine Railway Maintenance Files, Maintenance Office.

In 1970 the Navy made an evaluation of the Marine Railway and initiated the repairs needed to "make it functional." The estimated $10,000 in repairs was to keep the railway operating but in a limited capacity.[61]

In March 1971 the Navy declared the Marine Railway inoperative due to extensive slack in the hauling chains and other problems in operating the dock. Citing the 1968 Crandall report, the Navy estimated that necessary repairs to the railway would cost $188,000.[62] The necessary repairs were not made and there is no indication that the Marine Railway was operated after the spring of 1971.

Today the Marine Railway is maintained by the National Park Service. It is not operable. The machinery used to power the railway hauling gear is intact in the southeast corner of Building 24. The motor bears the following identification:

Alternating Current Motor
Type 31 75 BR
3 Phase
60 Cycles
200 HP
30 Min. Rating 55° C
570 RPM
Serial No. 170603
Wagner Electric Mfg. Co.
St. Louis, U.S.A.

C. Historical Data on Marine Railway Construction

The modern marine railway was developed in England and examples were being built in the United States by 1826. At that time Loammi Baldwin, civil engineer and designer of Dry Dock 1 at the Charlestown Navy Yard, examined such a structure being built in New

---

61. Maintenance Records, January 1971. Marine Railway Maintenance Files, Maintenance Office.

62. Maintenance Records, March 31, 1971. Marine Railway Maintenance Files, Maintenance Office.

York. Baldwin was interested in the New York railway because there were plans to build a marine railway in Boston. Baldwin sent a description of the marine railway to Captain Charles Tracy in Boston.[63]

The New York marine railway was 40 feet wide and the rails were laid upon and bolted to piles without stone foundation. Cast iron plates were fastened to the rails. The ship being hauled up was to be secured to the railway carriage by "triangular shores stepped upon the outside rails of the carriage and leaning inward towards the ship against the bends without using sliding blocks or the movable cross pieces" that were commonly used. Baldwin noted that Thomas Morton's plan included sliding blocks and movable cross pieces. Morton is credited with inventing the modern Marine railway.[64] The New York railway, rather than having cross pieces laid sloping toward the keel, had cross pieces laid horizontally. The pieces were fixed to the middle and side rails, "but fixed to cast iron knees and bolts in such a way that they may be taken out, if experience should show that this is best."[65]

The marine railway being built in New York was 500 feet long, 300 feet of which was underwater. The track sloped 5/8 inch to a foot. The timber work and the heads of piles below the low water mark were covered with zinc plates "to preserve the wood from the worms." There was no piling between the piles and the framework of the carriage.

It is interesting to note that Loammi Baldwin referred Captain Tracy to his brother, George Rumford Baldwin, for particulars on the New York Marine Railway. George Baldwin was the designer of the Boston Marine Railway in 1840 (see Illustration 18).

---

63. Letter, Loammi Baldwin to Captain Charles Tracy, February 22, 1862. William L. Clements Library, University of Michigan, Ann Arbor.

64. Cunningham, "Treatise on Dock Engineering," p. 541.

65. Letter, Loammi Baldwin to Captain Charles Tracy, February 22, 1826. William L. Clements Library, University of Michigan, Ann Arbor.

A slipway constructed in Dover, England in 1849 was enlarged in 1888 to a total length of 556 feet with a capacity of 850 tons. The slope of the railway was 1:18 and the width was 52 feet. The upper 370 feet of the slipway was constructed on filled land and the lower section rested upon the chalk bottom under water. A concrete bed was laid under the railway and fir cross-sleepers 12 inches by 6 inches and 32 feet long were placed in it. These cross pieces carried the longitudinals to which the cast iron rails were fastened. The cradle was built in four sections and traveled on six lines of rails. The rollers were made of cast iron around a Bessemer steel shaft.[66]

Marine railways similar to Marine Railway No. 11 at the Charlestown Navy Yard were being constructed as early as 1854 when the Crandall Engineering Company built a marine railway in East Boston. Developments and changes in railways during the later nineteenth and early twentieth centuries were, more often than not, made in the machinery used to haul a cradle out of the water rather than in the design of the railway itself. Materials of railway construction did carry with locality, of course. Steel rather than timber was used in waters where marine borers caused significant damage to timber structures.

When originally invented by Thomas Morton the machinery used to operate a marine railway consisted of "spur gears worked by manual power, horses, or the steam engine."[67] Hydraulic apparatus came into use about 1850 and a winding apparatus was used later in the nineteenth century. The hauling gears for the Marine Railway at the Charlestown Navy Yard are powered by an electric motor.

---

66. Cunningham, "Treatise on Dock Engineering," pp. 493-95.

67. Ibid., p. 541.

III. EXISTING CONDITIONS

CRANDALL DRY DOCK ENGINEERS, INC.
DEDHAM, MASSACHUSETTS 02026

PRELIMINARY REPORT ON

RAILWAY DRY DOCK C106

CHARLESTOWN NAVY YARD

A topside and underwater inspection of the abandoned 2000-long-ton railway dry dock at the Charlestown Navy Yard for the purpose of determining needed work to restore it to operating condition as an exhibit in the Boston National Historical Park was conducted in November 1977.

The findings are reported below. It will be necessary to remove a considerable amount of debris from the track before a test operation can be scheduled. Only after that can the full scope of the restoration effort be assessed. In general, however, it appears that the railway is in surprisingly good condition for its age and in view of the neglect of recent years.

Description

The Charlestown Navy Yard railway dry dock was one of several about this size designed by the old Crandall Engineering Company in connection with mobilization of resources for World War I.

It was designed for a capacity of 2000 long tons, employing four 2-1/4 inch steel chains and supported by three timber tracks, for a total length of 652 feet on an average grade of 1 to almost 14. The center track has 12-inch rails and the side tracks, 4-1/2 inch, all tapered in thickness along the length to economize on steel by taking advantage of the lighter net weight of the load buoyed up in the water.

The timber cradle is in two parts, 174 feet for the forward section, and 158 feet the aft section; there is an 18-foot fantail added to the stern.

During World War II, piles were doubled up on the side ways. To our best knowledge the last major work done was in 1954 when a modern roller system with bushed frames was installed.

Track

The track is raised several feet above the mud line. The uncovered portions of the support piles appear to be in good condition, and the buried sections would be protected from borer infestation and other deteriorating effects by the mud. The caps on the piles are in good condition. The wooden track is properly protected by board sheathing. Some of this sheathing is beginning to show signs of borer attack and should be watched for eventual replacement; some of it also needs to be refastened. The chain slides are in good condition.

The rail plate is in acceptable condition and the rail fastening pins are satisfactory.

Debris on the track at various places would prevent operation of the railway at the present time. There are many timbers randomly located on the track offshore that will have to be pulled off. Ballast boxes on the cradle that contained stone ballast have rotted, dumping a large amount of stone onto the track and the chains for the full length of the cradle; this, too, must be removed before the cradle can be operated. About 50 feet aft of the cradle and considerably further out there are cables across the track and backing chain that have to be removed.

There is no reason at the present time to believe that the track is out of line or grade.

Roller System

There is excessive play between the roller pintles and the bushings, probably caused by wear and/or corrosion of the pintles. This, perhaps in connection with a thinning of the cradle shoe plates, is allowing some roller frames to touch the bottom chord of the cradle. This condition does not need attention for the trial operation but should be corrected for the long run if the railway is to be considered "rehabilitated". Except for this, the whole roller system is adequate for the modest loads that would be expected to be imposed on it with the railway put back into operating condition as part of the Historical Park.

Cradle

The over-all condition of the cradle is fair to good. Some of the rods from the deck down to the low logs have lost significant metal and should eventually be replaced. Walers and diagonals are in good condition. The aft end of the cradle has suffered severe attack by marine borers, and although extensive replacement of members is not required in view of the intended use of the railway, the affected parts must be cut out and replaced by sound timber, preferably pressure-treated. In one area on the starboard side, aft, the bottom chord has been undercut about 2 inches by roller frames as mentioned above; correcting the condition to prevent worsening of the situation by building up the pintles or bushings and/or replacing the shoe plates is all that is necessary, and only if it is decided to proceed with restoration. The underwater sheaves are slightly but not excessively worn, and the sheave case is in good condition. As mentioned earlier, the stone ballast has mostly fallen from the cradle; if test operation shows that ballast is needed, some junk metal will serve very well.

Chains

The 2-1/4 inch hauling chain is reduced in size even to 1-15/16 inches in some places, but is adequate. The 3/4 inch backing chain is also acceptable.

Machinery

The old open-gearing hauling machinery is intact and should work. Cleaning up and lubricating are necessary prerequisites to trial operation.

Effort Needed Prior to Test Operation

The two essential areas requiring attention are the track, which has to be cleared to allow the cradle to move, and the hauling machinery, particularly the gearing, motor, and electrical controls.

A week and a half of work by a diving team supported by a work boat is deemed adequate to clear the track; the cost of this would be about $5,000.00.[1] If it is desired just to test the cradle's mobility with only a slight displacement, the clearing of the whole length of track can be deferred. As a minimum, however, the stone must be

1. In 1982 dollars, the figure would be $9,200.

removed from under the cradle, and this will require about a week's work by laborers and the diving team, with work boat support, for a cost of about $3,000.[2] Since CRANDALL does not have any laborers as employees, it is assumed that the Boston National Historical Park could supply them.

Cleaning and lubricating the machinery enough for brief operation, plus having a final check of wiring, contacts, etc. is estimated to cost not more than $500.00,[3] obviously exclusive of any unforeseen repair work that might be required.

Long-Term Work Needed

The most important action necessary in the long run is to arrest borer action to prevent further attack of the timber. For this, it will be necessary to replace certain members, but the over-all structural integrity is not threatened at this stage. Other minor replacements over a period of years would be desirable but are not essential. However, it should be remembered that the test operation can reveal defects not detectable in a static inspection. Many operating railways have rollers, rails, and chain that are worse worn than on this railway, and this one is not expected to haul anywhere near capacity loads.

Routine maintenance should be very simple--attention to lubrication, checking to assure there are no obstructions on the track prior to any operation, and 5-year inspections by dry dock experts.

Implicit in our judgments is the assumption that the railway will not be used to haul vessels of more than a fraction of its capacity; if the National Park Service intends otherwise, higher costs are involved in the restoration for the long run.

Summary

The railway dry dock appears to be in fundamentally sound condition, not requiring major work. The job of actually recommissioning it, however, is relatively expensive. In this case, the track debris is the costliest obstacle.

---

2. $5,525 in 1982.

3. $921 in 1982.

APPENDIX A

"Specification No. 2843 for Two Marine Railways
at the Navy Yards, Charleston, S.C., and Boston, Mass."

SEALED PROPOSALS, indorsed "Proposals for Marine Railways, Charleston, S. C., and Boston, Mass.," will be received at the Bureau of Yards and Docks, Navy Department, Washington, D. C., until 11 o'clock a. m., March 15, 1918, and then and there publicly opened, for one marine railway at the navy yard, Charleston, S. C., and one marine railway at the navy yard, Boston, Mass. Drawings and specification No. 2843 may be obtained on application to the bureau or to the commandants of the navy yards named. C. W. PARKS, *Chief of Bureau*. February 14, 1918.

1918

SPECIFICATION NO. 2843

FOR

TWO MARINE RAILWAYS

AT THE

NAVY YARDS, CHARLESTON, S. C., AND BOSTON, MASS.

UNDER APPROPRIATION 8296, "MARINE RAILWAYS AT NAVY YARDS AND STATIONS," ACT OF OCTOBER 6, 1917, ALLOTMENT NOS. 8296-2, BOSTON, AND 8296-1, CHARLESTON, S. C.

GENERAL PROVISIONS.

1. **The general provisions** entitled "General Provisions Forming Part of Specifications for Contracts for Public Works, Bureau of Yards and Docks, March 20, 1917," and "Addendum No. 1, dated November 3, 1917, to the General Provisions," shall form a part of this specification and of any contract based hereon. Copies of the said "General Provisions" and "Addendum" may be had on application to the Chief of the Bureau of Yards and Docks or to the commandant of any navy yard or naval station.

2. **Federal taxes** of every description shall be borne by the contractor. Such taxes shall not be included as a part of the cost of changes authorized under paragraph 17 of the "General Provisions."

SPECIAL PROVISIONS.

3. **General intention.**—It is the declared and acknowledged intention and meaning to provide and secure two marine railways of 2,000 gross tons capacity each; one to be located at the United States navy yard, Charleston, S. C., and one at the United States navy yard, Boston, Mass., complete in all respects and ready for operation.

4. **General description.**—Each marine railway shall consist of a cradle, machinery, machinery house and runways, all complete and ready for use. The cradle for Charleston shall be of structural steel, that for Boston shall be of timber, both shall have wood floors and blocks. They shall be in two sections, bolted together: shall run on rollers and shall be operated by electrically driven chain hoists. The machinery shall be suitably housed for protection.

The runway for Charleston shall consist of two tracks, 16 feet center to center. That for Boston shall consist of three tracks, 15 feet centers. The track irons shall be drift bolted to longitudinal timbers resting on timber piles. The runways shall be thoroughly braced.

5. **General dimensions.**—

	Boston, Mass.	Charleston, S. C.
	Feet.	*Feet.*
Length of ways	652	729
Distance center to center of extreme end keel blocks	332	332
Overall length of cradle	363	363
Clear distance between staging	42	42
Width over all	52½	52½

6. **Location.**—The marine railways shall be located at the navy yards, Charleston, S. C., and Boston, Mass., approximately as shown on the drawings. The exact location will be indicated by the officer in charge.

7. **Datum plane.**—All elevations given for each location refer to the respective yard datum, which is assumed to be mean low water at Charleston, S. C., and 100 feet below mean low water at Boston, Mass.

8. **Measurements.**—Steel tapes only shall be used in laying out all work under the contract. The tape used shall be compared from time to time with a Government standard tape.

In laying out the principal dimensions proper allowance shall be made for temperature and pull on tape if required by the officer in charge.

9. **Time for completion.**—The attention of bidders is directed to paragraph 9 of the "General Provisions" relative to the time of completion. No bid will be considered which is based on a time of completion in excess of 12 calendar months from the date of contract.

10. **Damages for delay, in accordance with the provisions of paragraph 13 of the "General Provisions,"** shall be at the rate of $50 per calendar day for each railway.

11. **Night work.**—If the contractor desires to carry on work at night or outside the regular hours, he shall make application to the officer in charge in ample time to enable satisfactory arrangements to be made by the Government for inspecting the work in progress. If granted permission, he shall light the different parts of the work in a manner satisfactory to the officer in charge and shall comply with all regulations.

12. **Employment of labor.**—The contractor shall not employ on the work any citizen of nations with whom the United States is at war, nor of nations allied to or friendly with nations at war with the United States. Furthermore, the officer in charge shall have the right to demand the immediate removal of any individual from the work, and where such demand is made the individual referred to shall be removed from the work and not again employed thereon. The right of removal shall apply to all work done by the contractor, whether on the site or elsewhere.

13. **Work not included in the contract.**—The following work will not be included in the contract: Such work and material as specified in paragraph 14.

14. **Work to be done and material to be furnished by the Government.**—The Government will dredge to the required subgrade as shown on the drawings over the offshore part of the site of the railway, so far as this may be accomplished by ordinary dredging operations, the dredges being water borne; also all necessary covering of the ways with back fill. The Government will build retaining walls at the inshore ends of ways, but the contractor shall prepare the site for such walls. The Government will remove such electric conduit, wiring, pipe lines, sewers, scrap bins, and any building above the surface of the ground as may interfere with the construction of the ways at Boston.

The Government will furnish without charge, except as hereinafter stated, bituminous coal which may be required for the work performed at the respective sites. Any expense connected with the removal of the coal from the station's stock or from cars or lighters, together with hauling charges, etc., at the respective stations, incurred on account of this contract, shall be borne by the contractor. The issue of coal to the contractor will be in such quantities and under such regulations as may be approved by the station. Each bidder shall make himself familiar with the local regulations and conditions under which the coal will be furnished. After award of contract, the successful bidder shall present to the officer in charge of the work a schedule of probable coal requirements sufficiently in advance to enable satisfactory arrangements to be made for such coal.

15. **Government utilities available.**—So far as the Government plant and the demands of the Government service will permit, the contractor may obtain electric current for power and light, and water from the yard supply, and may use the railroad tracks, rolling stock, and hoisting appliances of the yard systems, paying for the materials and services at the prevailing Government rates. The Government will furnish and install one meter, one switch, and in case alternating current is used, one transformer for electric current, also one meter and shut-off for water mains, all within the limits of the area assigned to the contractor. The contractor shall provide, maintain, and repair all further wiring, poles, lamps, and accessories and all further piping and fittings required to transfer the electric current and water to the different parts of the work. Compressed air may be obtained where available at prescribed rates. The Government will assume no liability for the failure of the supply of any of the above-mentioned utilities.

16. **Drawings accompanying specifications.**—The following drawings accompany this specification and will form a part of the contract. Said drawings are the property of the Government and shall not be used for any purpose other than that contemplated by this specification.

Bureau serial No.	Yard.	Sheet No. of 8.	Showing—
73698	Charleston, S. C.	1	General layout.
73699	do	2	General plan of cradle.
73700	do	3	Typical cross section.
73701	do	4	Details at inboard end.
73702	do	5	Drawhead details.
73703	do	6	Detail at outboard end.
73704	do	7	Machinery house.
73705	do	8	Details.

Bureau serial No.	Yard.	Sheet No. of 4.	Showing—
74493	Boston, Mass.	1	Location, plan, and retaining walls.
74494	do	2	General plans and sections.
74495	do	3	Machinery house.
74496	do	4	Details.

17. **Navy standard specifications,** as follows, are referred to in this specification. Copies may be obtained upon application to the Chief of Bureau of Yards and Docks.

Number.	Date.	Title.
59C1a	Jan. 1, 1917	Portland cement.
48S1c	Feb. 1, 1917	Structural steelwork.
59Cec	Feb. 1, 1916	Concrete and mortar and materials for.
52L1c	June 1, 1917	White lead.
52L2b	Oct. 2, 1916	Red lead.
52O1b	June 1, 1917	Linseed oil (raw).
52O2b	June 1, 1916	Linseed oil (boiled).
17T3	Nov. 5, 1912	Transformers, single phase.
17M2b	Mar. 1, 1916	Motors, induction.
33F1a	May 1, 1917	Tarred sheathing felt.
52B8	Feb. 2, 1914	Bituminous solution, etc.
52O7	Jan. 2, 1915	Creosote oil.
52C2a	Aug. 1, 1917	Carbolineum, etc.
	Sept. 15, 1917	Standards of design, reinforced concrete.

18. **Method of procedure.**—After the contract is awarded the contractor shall submit to the Chief of the Bureau of Yards and Docks a detailed statement, outlining the method that he proposes to follow.

19. **Drawings required of the contractor after the contract is awarded.**—The contractor shall submit to the Chief of the Bureau of Yards and Docks, for approval, before commencing the installation of any of this work, shop drawings of all structural steel framing, complete detail drawings of all timberwork, detail drawings of all machinery, machinery foundations and housing, details of bilge blocks, winches, sheaves,

and all fittings. He shall also submit such other drawings as may be required under paragraph 24 of the "General Provisions."

20. **Samples required of contractor after work is begun.**—The contractor shall submit to the officer in charge, for approval, samples of materials for concrete and hauling chains. The contractor shall also submit such other samples of materials as may be required whether specifically called for or not. Accepted samples may be used in the finished work. Materials shall conform to samples. The approval or acceptance of such samples shall not preclude the rejection of any material upon the discovery of defects previous to the acceptance of the completed work.

21. **Contours.**—Elevations of the ground in the vicinity of the work are indicated on the drawings. These elevations are referred for each location to the respective yard datum. Although these elevations indicate approximately the conditions that are likely to be found, intending bidders will have the privilege of examining the site of the work, and they should satisfy themselves as to the actual elevations.

22. **Buried constructions.**—Such information as the Government possesses regarding sewers, pipes, abandoned shipways at Boston, and other construction beneath the surface of the ground on the site of the work is indicated on the drawings. The Government does not guarantee that the constructions indicated or as shown on the drawings or that other buried construction will not be encountered and does not assume any risk or responsibility in connection therewith.

23. **Test piles.**—Records of test piles driven at the sites of the work are available for inspection at the Bureau of Yards and Docks, Navy Department, Washington, D. C., and at the navy yards for which the work is contemplated. All bidders shall base all their bids on the length of piles given in paragraph 39. Any increase in length will be paid for as hereinafter provided, under items 7 and 8.

24. **Borings.**—The Government has taken no borings on the sites of the structures. Intending bidders will have the privilege of examining the sites of the work and may use such data as the Government possesses of adjacent borings and excavations.

25. **Soundings.**—Soundings in the vicinity of the work are indicated on the drawings. They give depth below mean low tide. Although they indicate approximately the conditions that are likely to be found, intending bidders will have the privilege of examining the sites of the work, and should satisfy themselves as to the actual depths.

26. **Tides.**—The distance between mean high and mean low water is estimated to be 10 feet at Boston and 5.1 feet at Charleston.

27. **Warranty.**—The contractor shall warrant the complete work, except the bitumastic compound hereinafter mentioned, to be free from defects of workmanship or materials, for a period of one year from date of acceptance. He shall furnish a written warranty, satisfactory to the Chief of the Bureau of Yards and Docks, that he will make good at his expense any defects developing during this period. The bitumastic compound used for protection of steelwork shall be guaranteed for the period stated in the proposal to be furnished by the bidders.

28. **Sanitary regulations.**—Necessary sanitary conveniences for the use of laborers on the work, properly secluded from public observation, shall be constructed and maintained by the contractor in such manner and at such points as shall be approved by the officer in charge, and their use shall be strictly enforced. Upon completion of the work they shall be removed from the premises, leaving all clean and free from nuisance.

29. **Use of structure before acceptance.**—The Government shall have the right at any time during the construction of the structure to enter the same for the purpose of installing, by Government labor or by other contracts, any necessary work, or for any other purpose in connection with the installation of facilities, it being mutually understood and agreed, however, that the contractor and the Government will, so far as possible, labor to mutual advantage where their several works in the above-mentioned or unforeseen instances touch upon or interfere with each other.

30. **Limits assigned to contractor.**—The attention of bidders is directed to paragraph 6 of the "General Provisions" relative to the facilities furnished to contractor.

31. **Temporary buildings.**—The contractor shall erect at his own expense and remove as required by paragraph 6 of the "General Provisions" such temporary storage sheds, offices, houses, etc., as are usually required for this class of work, after approval by the officer in charge.

32. **Removal of rubbish.**—The attention of bidders is directed to paragraph 27 of the "General Provisions" relative to the removal of rubbish from the site upon completion of the work.

PREPARATION OF SITE AND BACK FILLING.

33. **Dredging.**—The Government will dredge the offshore part of the site of the railway to subgrade line shown on drawings, so far as the same may be accomplished by ordinary dredging operations, the dredges being water borne.

34. **Excavation and back fill.**—The contractor shall make all excavations required, on shore, or below water level, except as provided in paragraph 14. At Boston the contractor shall remove such portions of the adjoining quay walls as will be necessary to connect a new retaining wall thereto and excavate inshore from the quay walls sufficient to permit the construction of retaining walls subsequently by the Government. The Government will make all back filling necessary for the ways.

QUALITY.

35. **All materials and workmanship** shall be of the best quality of their respective kinds unless other grades are specifically mentioned and the acceptance of same is understood and agreed to be subject to the approval of the officer in charge.

36. **Cement.**—All cement shall be in accordance with Navy standard specification, referred to in paragraph 17.

37. **Concrete.**—All materials for concrete and mortar, including sand, broken stone, gravel, lime, and water, and the methods of mixing and placing, shall be in accordance with Navy standard specification, referred to in paragraph 17.

38. **Iron and steel, mill and foundry products.**—All structural steel, wrought or cast iron, used in the work shall fulfill the requirements of Navy standard specifications referred to in paragraph 17. Iron and steel for machinery, unless otherwise specified, shall be of the grade demonstrated by extended use to be best for the purpose which it will be required to serve. It shall be subject to all usual tests. In case of material taken from stock, a certified statement, satisfactory to the officer in charge, shall be furnished by the contractor to the effect that the material supplied is of the grade conforming to the intent of this specification.

39. **Round piles** shall be of sound North Carolina pine, winter cut from live timber. They shall be free from windshakes, checks, large or unsound knots, double crooks, bell ends and from other defects tending to impair their strength or durability. Two feet from the butt the diameter shall be not less than 14 inches and the point shall be not less than 7 inches in diameter, both measurements exclusive of the bark. Piles shall be so straight that a straight line joining the centers of the ends lies wholly within the body of the pile. Lengths shall be such as to give the required penetration, but all bidders shall base all their bids on piles being furnished by the contractor of such lengths to enable them to be driven with their points to the following elevations:

Boston, bents 1 to 40, inclusive, elevation point, 70; 41 to 70, inclusive, elevation point, 60; 71 to 130, inclusive, elevation point, 30; 131 to 170, inclusive, elevation point, 20; 171 to 195, inclusive, elevation point, 10.

Charleston, bents 1 to 30, inclusive, elevation point, 50; 31 to 150, inclusive, elevation point, 60; 151 to 216, inclusive, elevation point, 70.

Some test piles driven by the Government at Charleston are so located that they can be used by the contractor. Only the cost of cutting and fitting these piles shall be included in the bid.

40. **Timber and lumber.**—All timber except blocks and creosoted material shall be long leaf yellow pine of merchantable grade in accordance with the rules of the Southern Pine Association for grading timber dated January 1, 1917, and the lumber shall be grade No. 1 common in accordance with the rules for lumber dated April 1, 1917. All North Carolina pine shall be grade No. 1, in accordance with the rules of the North Carolina Association (Inc.), dated January 25, 1917.

41. **Keel and bilge blocks** shall be of American rock elm, American white oak, hard maple, or yellow birch. Only sound clear heart timber shall be used for blocks.

42. **Creosoted lumber** shall be North Carolina pine. Certain specified material for Charleston ways only shall be creosoted.

THE WAYS.

43. **The ways** shall consist of built-up stringers directly supported by piles. Each stringer shall consist of a base of two pieces, a mid section through which 8 by 12 inch ties pass, and a top piece slightly beveled to receive the roller plate. The whole shall be bolted together with 1 inch diameter drift bolts and attached to the supporting piles with 1 inch diameter drift bolts. For the Charleston ways, the sides, top, and ends of each stringer and tie below mean high water shall be covered with one layer of ship felt, well lapped and mopped at intersections and at junctions of ties and stringers, and then covered with 1-inch creosoted plank of North Carolina pine, well nailed to the stringers and ties, with 2½-inch galvanized cut nails.

Diagonal bracing between the runway tracks below mean low water, outboard shall be creosoted for Charleston ways only. The plank used to protect the ship felt, the wood portion of the spacers for rollers, and the plank used in the construction of the chain paths for the Charleston ways shall be creosoted to the extent of 16 pounds per cubic foot of wood. The wood shall be creosoted in accordance with paragraph 45.

At Boston where the ways cross the stone foundation walls of the old slip, the top stones shall be removed and a bed of concrete placed under the stringers of the ways as indicated on drawings.

44. **Longitudinal and traverse bracing.**—For the Boston ways longitudinal and transverse bracing of long-leaf yellow pine shall be provided as indicated on the drawings. They shall be connected to the piles with galvanized bolts and ogee washers. The bracing shall be finished neat with the outside line of piles.

45. **Creosoting.**—All lumber required to be creosoted shall be treated as follows: Subject the material for five hours to the action of live steam at a temperature of not less than 250° F. and not exceeding 275° F. After the pressure treatment, a vacuum of not less than 20 inches of mercury shall be created in the chamber, which shall be maintained for six hours. Oil shall then be admitted to the chamber. The vacuum shall be maintained while the oil is flowing into the chamber and until the chamber is entirely filled with oil. Sufficient pressure shall then be applied to the contents to force a penetration of oil of not less than 1½ inches and a total absorption of not less than 16 pounds of oil per cubic foot of wood. All creosoted timber that is cut or dapped for construction purposes shall have the cut or dapped parts protected with a coat of carbolineum.

46. **Pile driving.**—The piles shall be driven accurately in alignment and spaced as indicated on drawings. They shall be driven plumb to a firm and satisfactory bearing. The average penetration per blow for the last three blows of a 3,000-pound hammer falling 15 feet shall not exceed 1½ inches for Charleston, and 1¼ inches for Boston. Equivalent results shall be obtained if other methods of driving piles are employed. Care shall be taken that the piles are not injured in driving. Piles shall be cut off to exact grade and bevel (to obtain this result only machinery suited to the purpose shall be employed). The finished heads must be sound. Should piles of greater length than tabulated in paragraph 39 be required the increase shall be paid for at the rate bid under items 7 and 8.

47. **Traverse ties.**—The ways shall be tied by 8 by 12 inch ties spaced 10 feet center to center and fastened to the ways as indicated on drawings. They shall be protected for the Charleston ways by ship felt sheathed with plank as described under "Ways."

48. **Chain path.**—The chain paths shall consist of North Carolina pine treated with creosote oil to the extent of 16 pounds per cubic foot of lumber, for Charleston ways. For Boston ways the chain paths shall be long-leaf yellow pine, not creosoted. The paths shall be securely fastened to and carried by the crossties. The layer of ship felt protecting the ties on the Charleston ways shall be carried under the ties.

49. **Rail plates.**—For Charleston all rail plates shall be 10 inches wide. For Boston the center plates shall be 12 inches wide and the side plates 4½ inches. The thickness shall vary from inboard to outboard and approximately as follows:

Boston.			Charleston.	
Thickness of center track.	Thickness of side track.	Length.	Thickness.	Length.
Inches.	*Inches.*	*Feet.*	*Inches.*	*Feet.*
1	⅛	60	1	60
1⅛	1	60	1⅛	60
1¼	1⅛	360	1¼	400
1⅛	1	80	1⅛	100
1	⅛	92	1	109
		652		729

The rail plates shall be fastened to the stringers by countersunk drift bolts, spaced as indicated on drawings. The ship felt shall be carried under them and the top face shall be brought to continuous surface by wood fillers placed below the felt.

50. **Back-haul anchor.**—The back haul sheaves and casings shall be attached to braced timbers which shall transmit the pull to the ways. The sheaves shall be bushed with a hard anticorrosive metal and shall have steel pins. All steel and iron shall be protected by a heavy coat of bitumastic applied in accordance with paragraph 63.

ROLLERS AND ROLLER FRAMES.

51. **The cradle will travel on ranks of rollers, one rank being supported on each line of ways, and in turn supporting the corresponding runner shoe of the cradle.**

52. **Rollers.**—The rollers shall be of cast iron, cast with steel end spindles in place. They shall be of uniform size, truly cylindrical and free from defects. For Boston they shall be 4 inches diameter for 12½ inches in length for center track and 3¾ inches for 5 inches in length for side track, and for Charleston they shall be 4 inches diameter for 10½ inches in length. The end spindles shall be 1 inch diameter and shall project 3 inches, with not less than 2¼ inches bedded in the roller, the bedded ends shall be ragged or upset. All shall have flanges on both ends.

53. **Roller frames.**—The rollers shall be built in nests and held together at the required spacing by side bars composed of structural steel angles and wood with cast-iron spacing spools at intervals as shown on drawings. The wooden part of the side bars shall ride on the spindles of the rollers.

All holes for bolts and roller spindles shall be drilled or subpunched and reamed, and shall match each other exactly in opposite runner frames. All binding and splice bolts shall be neat lengths plus two threads. After being screwed up tight, the nuts shall be checked. The holes for the roller pins shall be 1¼ inches diameter in the angle and 1⅛ inches diameter in the wood bearer. The bearing piece shall be of North Carolina pine treated with creosote to the extent of 16 pounds per cubic foot for Charleston and of long leaf yellow pine for Boston. The nests shall be about 15 feet long and shall be connected together as indicated on drawings by 1¼-inch pins.

The roller spacing from inboard to outboard end shall be center to center about as follows:

Boston ways.			Charleston ways.	
Spacing center track.	Spacing side track.	Length.	Spacing tracks.	Length.
Inches.	*Inches.*	*Feet.*	*Inches.*	*Feet.*
9	12	390	12	413
12	15	45	15	45
15	18	30	18	45
		465		503

For each track there shall be provided two detached spare sections each 8 feet long with 12-inch spacing.

54. **Assembly** of roller frames and rollers shall be in accordance with the detail and diagram shown on drawings. The parts of the roller frames and rollers which will be permanently under water shall not be installed until the railway has been otherwise completed and made ready to be tested.

55. **Painting.**—The roller frames shall be painted with the specified shop coats, and when connected in the field shall be cleaned and coated with bitumastic solution and bitumastic enamel, as specified hereinafter for the cradle structural steel in paragraph No. 63.

BOLTS AND WASHERS.

56. **Bolts and washers.**—Bolts shall be of mild steel to conform with the Navy standard specification 48S1c referred to in paragraph 17. They shall have standard threads, heads, and nuts, and shall be supplied with washers as hereinafter specified. All bolts and nuts shall be galvanized after being threaded, the threads being recut if necessary. Drift bolts shall have countersunk heads. All bolts shall have washers under nuts, and when in contact with wood shall have washers also under heads. All washers shall be galvanized plate washers, except for the bracing for piles at Boston, which shall be cast-iron ogee washers.

57. **Galvanized material.**—All material which is described in this specification or indicated on the drawings as "galvanized" shall have a zinc coating equivalent to that produced by the following process: All pieces shall be entirely immersed in a solution of sulphuric acid and water. On removal from the solution the pieces shall be thoroughly brushed and washed with clean water. They shall then be immersed in an alkaline solution for a time sufficient to neutralize the acid completely. They shall then be washed with a jet of clean water and allowed to dry. After drying they shall be immersed in a bath of molten zinc covered with sal ammoniac. The coating shall be complete, uniform, and smooth. The galvanizing shall be done after all cutting of threads, shop work, or bending has been done and the pieces are ready to be placed in the structure.

THE CRADLES.

58. **The cradle** for Boston shall be built of timber, of sizes suited for the loadings given. The cradle for Charleston shall be built of structural steel as indicated on drawings. The projected length for each cradle, center to center of end keel blocks, shall be 332 feet. There shall be an overhang at the outboard end and the footwalk at the inboard end shall extend inboard to receive a removable crosswalk.

59. **Design and dimensions.**—The governing dimensions and the general design of the cradle and the sections of the principal members are shown on the drawings and shall be adhered to, except as specified hereafter. Modifications of details may be made only with the approval of the Bureau of Yards and Docks.

60. **The design** for the wooden cradle for the Boston ways has only been indicated on the plans. Bidders shall submit sizes with proposals in sufficient detail to permit checking for strength and for comparison. All designs shall be prepared with reference to the block loads and unit stresses given on drawings.

61. **Fabrication.**—The steel framing of the cradles for the Charleston ways shall be furnished, fabricated, and erected in strict conformity with the requirements of Navy standard specifications 48S1c referred to in paragraph 17, excepting such modifications thereof as may be mentioned herein.

62. **Riveting.**—The riveting shall be completed in accordance with the requirements of Navy standard specifications 4SS1c, for reamed work. In preparing and assembling the material, care shall be taken to make the contact surfaces touch throughout.

63. **Painting.**—As soon as the steel framing of the cradle for Charleston or of any section of it which for erection purposes is considered as a unit shall have been completed the surfaces shall be thoroughly cleaned with wire brushes, especial care being taken that all interstices and edge seams are entirely clean of rust, scale, burrs, or insecure paint of the shop coat. When clean and perfectly dry, the surfaces of the steelwork shall be coated with an approved bitumastic compound, liquefied with a thinner, to be supplied only by the manufacturers of the coating compound, in accordance with the requirements of Navy standard specifications 52B8, dated February 2, 1914. After the first coat has hardened a second coat of the compound, liquefied by heat without the addition of any thinner, shall be applied over the first coat. Where possible, at seams, butt joints, or any other interstices, the compound shall be poured and spread lightly with brushes. The general purpose of the work shall be to obtain an unbroken, impervious coating of the compound, about one-sixteenth inch thick over the entire surface of the steelwork, sealing all seams, joints, interstices, and rivet heads. The coating shall be applied before any floor timberwork, blocking, or galvanized-iron fittings are installed. The bitumastic compound used shall be a commercial preparation guaranteed to withstand for a satisfactory period the action of sea water and the prevailing climatic conditions, and to fully protect the steelwork from corrosion during the guaranteed period. Bidders shall state in their proposals the trade names of the compounds they propose to use, the names of manufacturers, and the guaranties they (the bidders) will assume.

64. **Deck.**—The cradles shall be floored with long-leaf yellow-pine planks 3 inches thick SIS, secured to long-leaf yellow-pine timbers with two galvanized boat spikes ¼ by 6 inches at each intersection. The timbers shall be S2E and of the sizes indicated on the drawings. Planks shall break joints and shall be laid with ¼-inch open joints.

65. **Keel blocks** shall be made from the timber specified in paragraph 41. For as much of the length as is possible the three top tiers of blocks shall be uniform in height so that upon removal of each tier the top of blocks will remain on the same slope of ⅛ inch in 1 foot. Blocking shall be surfaced all around, with protruding corners chamfered ½ inch on each face. Where necessary the bottom of blocks shall be beveled for bearing on stringers and beams to bring the blocks into a truly vertical position. The dowels, dog clamps, and bolts shall be of steel, all heavily galvanized. Keel blocks and bilge-block slides shall be securely fastened to supporting beams.

66. **Bilge blocks** shall be made of the same kind and quality of timber as the keel blocks. Bilge-block timber shall be surfaced on all sides and shall have no sharp edges, excepting on top and bottom faces. They shall be of the releasing type, so constructed that the block may be released under full load and replaced easily, positive in action, and strong enough to carry not less than 60,000 pounds. The fittings and fastenings shall be accurately and neatly framed to the timber in accordance with detail drawings.

All fittings and fastenings of steel or iron, including bolts, guides, links, chains, pulleys and pulley housings, winches, and operating-device block for raising and lowering, shall be painted with bitumastic paint. Chain fastenings shall be adjusted so that blocks will travel smoothly on their slides without binding on the guides.

67. **Bootjack** shall be of long-leaf yellow pine and built to dimensions shown on the drawings. Eye bolts for the connection of the bootjack shall be provided where indicated. Care should be taken to center the bootjack accurately on the center line of the cradle.

68. **Walkways.**—Plank walkways of long-leaf yellow pine shall be installed on staging on each side of the cradle, as shown on the drawings. All fastenings of timber and planking to the steelwork shall be made with galvanized carriage bolts. Plank shall be 2-inch SIS. Where cleats are installed the staging shall be reinforced for the cleat fastenings as shown on the drawings. Galvanized-steel ringbolts shall be installed where shown on the drawings.

69. **Gauge.**—A gauge shall be installed at each cradle head, so mounted as to indicate the depth of water, in feet, over keelblock 1. The gauge shall be made on 8-inch steel channel section, with Arabic numerals of cast iron, 6 inches high, attached to it by round-head stove bolts. The numerals shall be painted white. The body of the gauge shall be painted with the bitumastic paint specified for the framing before attaching the numerals.

70. **Ladders.**—Four steel ladders shall be installed where shown on drawings, leading from the deck to the walkway. Ladders shall be secured in place with bolts.

71. **Drawhead.**—A special framing shall be installed, connected to the cradle framing proper, substantially as shown on the drawings. The sheaves shall be of cast iron. Their accessory parts shall have a capacity to withstand the chain pulls as given on the drawings. Sheaves shall be bushed with approved anticorrosive metal and shall turn on forged, finished steel pins. Idler sheaves shall be installed where necessary. Lubrication of the main sheaves shall be provided by an approved method. All parts necessary to make the drawhead efficient as a whole in transmitting the pull to the cradle shall be supplied, whether or not they are shown on the drawings or called for by the specifications.

72. **Cast-iron cleats.**—Four large cleats 24 inches over all and 8 small cleats 18 inches over all of the pattern and dimensions shown on drawings shall be installed in the positions indicated.

HAULING CHAINS.

73. **Hauling chains** shall be made of the open-link type with straight sides, from the best reworked iron, having a tensible strength of not less than 51,000 pounds, and not more than 53,000 pounds per square inch, an elongation of 25 per cent in 8 inches, and a reduction of area of 40 per cent. The major portion of the hauling chains shall be, Boston 2⅜ inches, Charleston 2⅛ inches, and the balance covering the outer portion shall be tapered down to, Boston 1⅞ inches, Charleston 1⅝ inches, as detailed on sheet. Each size of chain shall be proof tested in accordance with the following table and shall show by test a breaking strength of not less than the amount shown in table.

Diameter of iron.	Proof test in pounds.	Breaking test in pounds.
2⅜ inches	166,770	352,500
2⅛ inches	149,648	316,400
2⅛ inches	133,264	282,200
2 inches	118,373	256,000
1⅞ inches	104,706	219,800
1¾ inches	90,552	191,400
1⅝ inches	77,920	165,100

All chain 1¾ inches or over shall be welded on the side of the link. Sizes under 1¾ inches shall be welded at the end provided the welded ends are finished true and circular and at a diameter of 1.04 of the nominal diameter. These hauling chains shall be made accurate and uniform in pitch and shall work over the sprocket wheels smoothly and with a proper fit. The links must be fair and straight, so that no twist shall accumulate to over 20° in any part or the whole of the chain. All tests of the material from which the chains are made shall be made on the full size of the bar.

74. **Length and sizes of one line of hauling chains.**—

	Outside chains.	Inside chains.
Boston (all links 9½ by 2¾ inches inside measurements; four lines of chain are required):	*Feet.*	*Feet.*
2¾ inches	458	446
2¼ inches	50	50
1¾ inches	53	50
	561	546
Charleston (all links 8¼ by 2¾ inches inside measurements; four lines of chain are required):		
2¼ inches	518	506
1¾ inches	56	56
1¾ inches	62	59
	636	621

EQUALIZER
43 LINKS – 32.25'

75. **Back-haul chains.**—The back-haul chains shall be of a high-grade B B, machine-made close-link chain. Those for Boston shall be 1 inch diameter and shall be proof tested to 27,100 pounds. Those for Charleston shall be ⅞ inch diameter and shall be proof tested to 20,680 pounds.

ELECTRICALLY DRIVEN HOIST.

76. **General design.**—The hoist shall be designed and built in general conformity to the accompanying drawings. The design as a whole, and that of all individual details, shall be in accord with the best practice for heavy hoisting machinery. The motors shall be of ample capacity, in no case less than 200 horsepower, and shall comply with the requirements of paragraph 89 of this specification.

77. **Capacity.**—The capacities of the hoists shall be a total maximum chain pull of 556,000 pounds at a speed of not less than 9 feet per minute for the ways at Boston and 450,000 pounds at 12 feet per minute for the ways at Charleston.

78. **Gears, sheaves and wheels.**—Gears shall be moulded cast steel, cast-iron or forged steel. The motor gears shall have teeth cut from the solid, and from materials selected by the machinery builders and certified by them to be in accord with the best practice. All castings shall be sound, true castings. They shall conform in physical properties to the requirements of Navy standard specifications 48SIc, dated February 1, 1917. The acceptance by the Government of castings prior to installation and performance in the finished work will be provisional only.

79. **Shafting.**—All shafts shall be steel forged and turned. Shafts shall be liberally proportioned for both bending and torsional stresses, where both occur.

80. **Bearings.**—The bearings of the winch shafts and their driving shaft shall be in frames of cast iron or of cast steel, continuous on each side of the machine. Each side may be in sections, if desired, strongly bolted with fitted bolts on contact surfaces. The nuts of all foundation bolts shall be faced and shall bear on finished surfaces when in place. The journal bearings throughout shall be supported either in the main frame or on heavy floor stands of suitable pattern.

81. **Band brake.**—A band brake of sufficient capacity to hold the maximum load shall be installed in the position shown.

82. **Motor brake.**—The motor shaft shall be supplied with a brake arranged to be automatically applied in case current is interrupted.

83. **Lubrication.**—Efficient and convenient means of lubricating properly all journals or other moving surfaces requiring lubrication shall be provided.

84. **Control of operations.**—The motor control shall be central in a group of control devices to be installed in the relative positions shown on drawings. The control devices shall include beside the special electrical requirements specified under "Electrical equipment," the following:

(*a*) Wheel, screw and floor stand for band brake clutch.
(*b*) Lever for disengaging pawl on main hoist.
(*c*) Lever for operating motor brake of main hoist.
(*d*) Controller.
(*e*) Clutches.

All levers shall be confined in suitable quadrants with properly located notches, and shall be provided with grip-lift latches for locking them in position.

85. **Pipe railing.**—A pipe railing shall be furnished and installed as a protection for the hoist in the machinery house. Railing shall be 3 feet high and shall have post and top and bottom rails, 1½-inch diameter black steel pipe with malleable cast-iron screw fittings. Details shall be submitted for approval. All material shall be given one coat of approved paint before shipment.

BILGE-BLOCK WINCHES.

86. **Bilge-block winches.**—Hand winches for hauling the bilge blocks shall be of cast iron, accurately drilled and fitted, and shall be securely bolted in place. Winches shall have sprocket wheels to fit the bilge-block chain, to work freely and hold securely. Sheaves shall be of iron, brass bushed. Winches and sheaves shall be galvanized and subject to the approval of the officer in charge.

87. **Chains.**—The bilge-block chains shall be of a high grade, machine made, close-link steel chain, heavily galvanized. All fittings and connections shall be sufficient to develop the full strength of the chain. Samples of all chains proposed to be furnished, of sufficient length for physical test, shall be submitted to the Bureau of Yards and Docks.

ELECTRICAL EQUIPMENT.

88. **General.**—The electrical equipment shall be furnished and installed complete and shall include a motor for the operation of the hoisting machine, controlling equipment, transformers, and a high-tension switchboard panel, disconnecting switches, together with all necessary interconnecting wires and cables.

89. **Motor.**—This shall be a polar-wound, 3-phase, 60-cycle, 220-volt induction motor of not less than 200 horsepower capacity. The horsepower rating to be based on 30 minutes continuous operation at full load with a resultant temperature rise of not more than 55 degrees centigrade. In the actual operation of the hoist at its specified pulling capacity the current input to the motor shall not exceed its rated current. Except as to the temperature requirements the motor shall conform to Navy standard specification 17M2b, type A (open), Class IV intermittent duty, constant speed, referred to in paragraph 17.

90. **Controlling equipment.**—There shall be furnished a complete control equipment consisting of a drum controller, and a rheostat for the secondary circuit of the motor. The control equipment shall be designed for a three minute starting duty, and to give approximately 35 per cent torque on the first point, 70 per cent torque on the second point and 100 per cent on the third point. The control equipment shall provide overload and no voltage release protection.

91. **Transformers.**—Provide three single-phase, 2200/220/110-volt, oil-cooled transformers and connect same in closed delta so as to give 220-volt three-phase secondary current. The middle point of the low tension winding of one transformer shall be connected to the ground. The transformer bank shall have 1 kilovolt ampere capacity for each 1.1 horsepower of the motor. Transformers shall conform to Navy Standard Specification 17T3, referred to in paragraph 17. Bids will also be considered on an equivalent three-phase transformer.

92. **High-tension switchboard panel.**—The high-tension switchboard panel shall consist of a marine finished marble slab equipped with a triple-pole automatic oil switch with time-limit relays and overload release coils, a 3-phase, 60-cycle, switchboard watt-hour meter with two current and two potential transformers for measuring 2,200 volt current, and a lamp bracket with reflector and lamp. Rear of the panel to be protected by a wire mesh or grille, so as to prevent accidental contact with live parts.

93. **Disconnecting switches.**—Near the point of entrance of feeder cables in the machinery room provide three single-pole 2,200-volt air-brake disconnecting switches and a switch hook with wood handle.

94. **Wiring.**—Beginning at the disconnecting switches, the contractor shall furnish and install all wires, cables, and conduits necessary for the operation of the hoisting machinery. Wires and cables shall be installed in galvanized conduits and, with the exception of the wires to the rheostat, shall consist of double-braided rubber-insulated conductors suitable for the voltage with which used and in strict accordance with the National Electrical Code. Wires between motor slip rings and rheostat shall be insulated with a suitable fireproof asbestos braid. The capacity of cables shall be determined from the tables of the National Electrical Code and shall be based on the current required by the motor at 25 per cent overload.

95. **Data required with bid.**—The following data are required with each bid, and failure to furnish same may render a bid informal:

(1) Motor:
- (*a*) Rated horsepower.
- (*b*) Synchronous and full-load speed.
- (*c*) Power factor and efficiency.
- (*d*) Maximum starting torque.
- (*e*) Maximum running torque.
- (*f*) Line current for starting under full-load torque.

(2) Controlling equipment:
- (*a*) Itemized list of material.
- (*b*) Capacity and make of instruments.
- (*c*) Cuts and description.

(3) Switchboard panel:
- (*a*) Itemized list of material.
- (*b*) Dimensions.

(4) Transformers:
- (*a*) Capacity and name of manufacturer.
- (*b*) Full-load core and copper loss.
- (*c*) Regulation.
- (*d*) Weights and dimensions.

(5) Disconnecting switches:
- (*a*) Capacity.
- (*b*) Description.

FOUNDATIONS AND MACHINERY HOUSE FOR HOIST.

96. **Foundation for hoist.**—The foundation for the hoisting machinery shall be 1-2½-5 concrete supported on piling and shall be built in general accordance with the specification and accompanying drawings. Machinery foundations shall freely meet the requirements of the equipment.

97. **Machinery house.**—The house for the hoist shall be a one-story building erected in accordance with this specification, and accompanying drawing. The house resting on a concrete and pile foundation shall have concrete pilasters, wall girders, floor and sills, brick walls, metal sash, wood doors, wood roof covered with wood sheathing and prepared roofing.

EXCAVATION, FILLING, AND GRADING.

98. **Work required.**—The contractor shall excavate for the foundations for machinery and for machinery houses, trenches, conduits, etc., and shall do all the filling, grading, and handling of dirt necessary for the proper completion of the building.

99. **Excavation.**—The contractor shall excavate to the necessary dimensions for all work required by the drawings. Any conditions encountered during excavation that may interfere with the execution of the work as indicated on the drawings shall be immediately reported to the officer in charge. If the interference is such, in the opinion of the officer in charge, as to require any departure from the work as shown by the drawings and specification, the increase or decrease in contract price due to such change will be determined under the provisions of paragraph 17 of the "General Provisions."

100. **Filling.**—Back fill around masonry and in the trenches shall be carried on as directed by the officer in charge. All back fill shall be tamped thoroughly in layers or puddled and settled into place. No filling or grading will be required of the contractor in the area inshore of the machinery house.

101. **Timber piles** shall be furnished and driven in accordance with this specification and the accompanying drawings. The depth to which piles under the machinery house and foundations shall be driven, will be determined by the officer in charge.

CONCRETE.

102. **Concrete work.**—Concrete and concrete materials and work on same shall be in accordance with Navy standard specifications Nos. 59C2c, 59C1a, and standards of design, reinforced concrete, referred to in paragraph 17.

103. **Plain concrete.**—Plain concrete shall be used for the machinery foundations and filling for the lower chords of cradle.

104. **Reinforced concrete floor** shall be mixed in the proportion of 1 part of cement to 2 parts of sand and 4 parts of broken stone or gravel. Cleavage joints shall be formed at the intersections of the floor and the walls. Floor shall have a wearing surface ¾ of an inch thick, composed of 1 part of cement to 2½ parts of sand. The wearing surface shall be applied immediately after the base has been laid and before it has taken an initial set. It shall be troweled to a hard surface and shall be marked with a sharp jointer into sections about four feet square.

105. **Reinforced concrete** shall be designed in accordance with the specifications for "Standards of design, reinforced concrete."

106. **Reinforcement for concrete.**—Reinforcing metal for concrete shall be of the sectional area indicated on the drawings, and shall conform to the requirements of Navy standard specifications for structural grade mentioned in paragraph 17.

107. **Concrete sills** for the windows and doors of the building shall be cast on the ground and shall be placed in the walls after the concrete has thoroughly set. Sills shall be formed with wash, lugs, and drip.

108. **Finish of exposed concrete surfaces.**—All exterior exposed vertical surfaces shall be of uniform color and even appearance, free from pits, fins, grain marks, stains, and inequalities of mixture. Care shall be taken in depositing to spade between the concrete and the forms to bring the finer portions to the surface. Every effort shall be made to avoid visible lines of juncture between concrete deposited at different times. Surfaces shall be kept wet until concrete has thoroughly set. In no case shall any loose material be left on the finished surfaces.

CARPENTRY AND JOINERY.

109. **Work required** includes all framing and finishing in wood necessary for the proper completion of the buildings in accordance with the drawings, this specification, and intent thereof. The contractor will be held responsible for all material and labor necessary to finish the building throughout.

110. **Grading lumber.**—All lumber shall be graded in accordance with the rules of the Southern Pine Association, dated April 1, 1917.

111. **Framing** shall be done in a rigid and workmanlike manner. The dimensions of the timbers and method of framing shall be as indicated in the drawings. Roof rafters shall be No. 1 common yellow pine, and exposed sheathing shall grade No. 2 clear.

112. **Roof sheathing** shall be dressed from 1¼ inch by not less than 6-inch boards, No. 1 common, tongued and grooved, laid close, and well nailed. Sheathing shall be surfaced one side.

113. **Door frames** shall be dressed from 2-inch No. 2 clear stock, flat grain, rabbeted for doors, and shall have slightly rounded edges.

114. **Setting frames.**—Door frames shall be set before the masonry is built around them. The frames shall be anchored to the masonry jambs as the jambs are built.

115. **Calking of frames.**—Door frames shall be thoroughly calked with mortar to make them perfectly weather tight on all sides.

116. **Doors** shall be built up as shown, of two layers of 1 by 6 inch grade No. 1 common yellow pine sheathing and 1¼-inch stiles and rails. The sheathing on the hinged side of doors shall be laid diagonally, and on the other side it shall be laid vertically. The layers shall be fastened together by wrought-iron clinch nails driven in flush and clinched so as to leave smooth surfaces on both sides of door.

BRICKWORK.

117. **Work required.**—Work required includes the construction of exterior wall panels.

118. **Bricks.**—Bricks shall be dark-red, hard-burned common bricks. They shall be run-of-kiln, of even shade and uniform size, and shall have sharp and true edges and corners. No soft, underburned, or overburned brick will be accepted. The exposed faces of brick walls shall be laid with the same brick as specified above, except that they shall be selected.

119. **Mortar for brickwork.**—All brickwork shall be laid in lime-cement mortar in accordance with "Navy Standard Specifications 59C2c," referred to in paragraph 17. The use of retempered mortar will not be permitted.

120. **Bond of brickwork.**—First course shall be a header course. All other brickwork shall be laid up in common or running bond with every sixth course a header course.

121. **Joints for brickwork.**—Joints of brickwork shall be uniform. Brickwork shall be laid four courses to 11 inches in height. Joints of exterior work shall be finished weathered. Joints of interior work shall be flush joints.

122. **Laying brick.**—All bricks shall be thoroughly wetted before being laid except in freezing weather. All bricks shall be laid in full beds. All joints shall be pushed full and the work shall be thoroughly slushed with mortar at every course. Grouting will be permitted only at such times as directed. All brickwork shall be built level, plumb, square, and true, regular or irregular, as required, to the full dimensions indicated, and in perfect bond, as specified herein. Header courses shall in all cases be bonded through the walls.

123. **Anchoring and bracing.**—Door frames shall be anchored to brickwork. All anchors, ties, bolts, and dowels necessary for the proper completion of the work shall be furnished and installed as required.

124. **Cleaning down and replacing.**—At the completion of the building, or when directed by the officer in charge, all damaged work shall be replaced or made good, and all work shall be washed down, cleaned, and painted where necessary. All brick shall be washed down with a weak solution of muriatic acid and thoroughly rinsed with clear water.

ROOFING.

125. **Ready-to-lay roofing.**—The roof shall be covered with sheathing as specified in paragraph 112. The roof shall then be covered with a 3-ply ready-to-lay asphalt or tar impregnated felt, having a slate-colored

finish. The felt shall weigh not less than 55 pounds per square. Roofing shall be laid with rust-proof, large-head roofing nails, and the laps shall be cemented. The roofing shall be applied according to the manufacturer's directions.

METAL SASH.

126. **Work required.**—The drawings indicate the area of steel sash required. Each bidder shall submit with his proposal the names of manufacturers of the sash which he intends to use. The contractor shall submit to the officer in charge, for approval, detail drawings, showing sash and operating devices.

127. **Steel window sash** shall be of a standard commercial type with rolled steel bars not less than 1¼ inches deep. One-half the sum of the weights per linear foot of vertical and horizontal inner bars or muntins shall be not less than 0.9 pound per linear foot. The outside bars shall weigh not less than 1.2 pounds per linear foot. All members of the sash shall be rigidly connected together, either by welding or by some other approved method. Provisions shall be made for fastening the steel sash to the masonry. Bolts and clips so required shall be furnished by the contractor under this item. Ventilating units shall be perfectly and substantially fitted and so pivoted as to be operated easily by hand. The pivot construction shall be substantial. Sash shall be coated by being dipped in an approved paint prior to shipment.

HARDWARE.

128. **Work required** includes all hardware necessary for the complete finish of the work in accordance with the drawing and specification and the intent thereof. The double doors shall be hung with heavy wrought-iron hinges, and provided with suitable locks to be approved. Foot bolts and chain bolts 6 inches long shall be provided at bottom and top of the standing leaf of the double doors.

129. **All hardware** used shall be submitted to the officer in charge for approval.

PAINTING AND GLAZING.

130. **Work required** shall include all painting and glazing necessary to make the building complete. Any work not specified but without which the building will not be complete as to painting and glazing, shall be treated in the same manner as other similar work.

131. **Materials** shall be of the best of their respective kinds, conforming to the best commercial practice, satisfactory to the officer in charge. They shall be delivered at the site of the building in original packages and shall be subject to tests at all times.

132. **General character of the work.**—All finished surfaces shall be left smooth, even, and free from any defects. All brushwork shall show even coatings, free from brush marks or corduroy. No coat of paint shall be applied until the undercoat is dry. No coat of paint shall be applied to wet or damp surfaces.

133. **Glazing.**—All glass shall be ¼ inch thick rough "wire glass," well bedded in putty and sprigged and puttied in a first-class manner. All glass shall be left clean and whole upon completion of the building.

MISCELLANEOUS.

134. **Test.**—Upon the completion of the work the contractor shall conduct working tests of the marine railway by docking a ship or ships to be supplied by the Government for that purpose. Should no ship approximating the dead weight desired be available, two or more smaller craft may be substituted. The tests shall be made in the presence of the officer in charge and under his general direction. The Government will install transmission lines, will connect the same to the contractor's work at the side of the hoist house, and will supply current for the tests.

135. **Proposals.**—Proposals on the Government forms will be understood to imply construction in strict accordance with the letter and intent of the Government plans and specifications.

136. **Modifications.**—Bidders who desire to modify any part of the Government plans shall state in a separate communication to be inclosed with the Government form: (*a*) The modification or modifications proposed; (*b*) the change to be made in the price named in the Government form by reason of the proposed modification, and shall inclose all necessary information, including drawings, for a full understanding of the changes proposed.

COMPETITIVE BIDS ON THE BASIS OF COST PLUS PERCENTAGE.

NOTE.—Paragraphs 137 to 156, inclusive, apply only to bids on the basis of cost plus percentage and to a contract awarded on such a basis.

137. Under items Nos. 4, 5, and 6, bids are also invited on the basis of cost plus percentage, each bidder to name under this item the percentage fee on which he will undertake the work, this percentage to be based on the bidder's estimate of cost, which estimate will accompany the bid.

138. **Definition of "Cost of the work."**—The items of cost which will be paid for by the Government and upon which the contractor's percentage fee will be based are hereby defined as follows:

(*a*) All labor and material applying to both temporary and permanent construction, exclusive of plant. "Plant" is hereby defined as large equipment or devices ordinarily moved from place to place and usually available on completion of the work for use at other places. Examples of items included under term of "plant" are derricks, engines, boilers, air compressors, concrete mixers, pumps, hoists, power-driven tools, motors, etc.

(*b*) Loading and unloading of the contractor's plant, both at the contractor's yards and on the site of the work, together with transportation of same to and from the work, provided that the distance from which and to which the plant shall be transported shall be subject to the approval of the officer in charge.

(*c*) Transportation to and from the site of the necessary skilled men for the economical and efficient prosecution of the work. The necessity for such transportation shall be determined by the officer in charge. Such transportation shall not involve repeated travel.

(*d*) Traveling expenses of any of the officers or engineers of the contractor when such travel is necessary. The necessity for such transportation shall be determined by the officer in charge.

(*e*) Salaries of resident engineers, superintendents, timekeepers, clerks, and other employees of the contractor's local office at the site of the work. No "overhead" expenses at the contractor's principal office or salaries of engineers or officers employed at the principal office shall be included in the cost of the work, nor shall the salaries of officers or engineers who may visit the work be included in the cost.

(*f*) All necessary expenses of the contractor's local office at the site of the work, such as telegraph and telephone service, expressage, postage, etc.

(*g*) Installation and dismantling of the contractor's plant, as well as the cost of necessary repairs and maintenance of same while employed on the work, provided that such repairs and maintenance shall not include ordinary wear and tear, and provided further that all plant shall be in good state of repair when delivered on the work.

(*h*) All hand tools purchased new and supplies necessary for the work. Such tools and supplies shall be the property of the Government on the completion of the work, or the same may be removed by the contractor

and allowance made therefor at an agreed upon inventory value. In any case, the course to be followed shall be subject to the approval of the officer in charge.

(i) The cost of liability insurance to protect both the public and the contractor from damage due to possible injury or loss incidental to the work.

(j) Engineering and drafting expenses actually incurred in connection with the preparation of detail drawings. Such cost shall include the cost of prints. The force employed and the charges made for such drawings shall be subject to the approval of the officer in charge.

139. **Additional elements of cost.**—All elements of cost not included in the above subdivisions (a) to (j), inclusive, shall be covered by the percentage fee, and such elements will not be otherwise paid for. In case the contract is let on a percentage basis, the contractor shall furnish without charge, other than the commission or fee, his business and purchasing system, engineering skill and experience, skilled organization, patented rights and generally his ability to organize and equip the work with experienced men.

140. **Detailed estimate of cost.**—Each bid on a percentage basis shall be accompanied by an estimate in detail showing the bidder's estimate of the actual cost of the work, exclusive of contractor's fee; this estimate to be subdivided under the heads of "Labor" and "Material," and also under the subdivisions (a) to (j), inclusive, as named above. The estimate for labor shall be itemized showing the number of hours of the various classes of labor employed and the rates of wages for each class of labor for each subdivision of the work, and, similarly, the estimate for material shall be subdivided in such a manner as to be subject to ready analysis.

Only such items and classes of labor as are covered in detail in the contractor's estimate of cost will be adjusted in case of increase in prevailing rates of wages described in paragraph 143. In accepting the contractor's estimate as a basis for contract, it shall be distinctly understood that the Government assumes no responsibility for the accuracy of such estimate, either as regards rates of wages, or number of hours of labor, or otherwise. The adjustment in the estimate of cost described in paragraph 143 will be made only in case there is an actual increase in prevailing rates of wages after award of contract, and such adjustment will be made only to the extent of such increase in prevailing wages and will be applied only to the number of hours of labor given in the estimate. If the bidder names in his estimate a rate of wages below the prevailing rate, no adjustment will be made unless an increase takes place in the prevailing rates, in which case the rates named in the estimate will be increased by the amount of the increase in prevailing rates, the total adjustment being based on the number of hours given in the estimate for the particular class of labor affected.

141. **Sliding scale fee.**—In order to establish a community of interest between the contractor and the Government, the contractor's fee named in his bid will be reduced on a sliding scale, as hereinafter stated, in case the actual cost of the work shall prove greater than the estimated cost of the work, as named in the contractor's bid, and similarly, the contractor's fee will be increased on a sliding scale as hereinafter stated, provided the actual cost of the work shall be less than the estimated cost of the work as named in the contractor's bid. The contract will provide for payment to the contractor of the following percentages of fee or compensation, these percentages to be based on the actual cost of the work, items of cost being defined as heretofore stated. If the actual cost of the work is 110 per cent of the contractor's estimate, the contractor's percentage fee shall be 82½ per cent of the percentage fee named in his bid; if the actual cost of the work is 120 per cent of the contractor's estimate, the contractor's percentage fee shall be 65 per cent of the percentage fee named in his bid; if the actual cost of the work is 130 per cent of the estimated cost named in the contractor's bid, the contractor's percentage fee shall be 47½ per cent of the percentage fee named in his bid In case the actual cost of the work is 140 per cent of the estimated cost named in the contractor's bid, the contractor's percentage fee shall be 30 per cent of the percentage fee named in his bid, and in case the actual cost of the work exceeds 140 per cent of the estmated cost of the work, as named in the contractor's bid, no further fee shall be paid to the contractor. Similarly, in case the actual cost of the work is 90 per cent of the estimated cost of the work, as named in the contractor's bid, the contractor's percentage fee shall be 117½ per cent of the percentage fee named in his bid; if the actual cost of the work is 80 per cent of the estimated cost of the work, as named in the contractor's bid, the contractor's percentage fee shall be 135 per cent of the fee named in his bid. For any intrevening ratio of the actual to the estimated cost, the contractor's percentage fee shall be proportional to the values above given. In other words, the contractor's percentage fee shall be determined in all cases by the following formula: $p = 275 - 7/4\ r$ where r is the ratio of the actual cost to the estimated cost named in the contractor's bid, expressed in the form of a percentage, and p is the ratio of the percentage fee actually paid to the percentage fee named in the contractor's bid, p being expressed in the form of a percentage, provided that, in case the actual cost of the work is 140 per cent of the estimated cost contained in the contractor's bid, or greater, the contractor's percentage fee shall be constant and equal to 30 per cent of the percentage fee named in the bid, this revised percentage fee being applied to 140 per cent of the estimated cost of the work contained in the bid. To illustrate: Assume as a concrete case that a bidder estimates a piece of work to cost $100,000 and names 10 per cent thereof as his fee; then, in case the actual cost of the work proves to be $90,000, the percentage fee actually paid to the contractor will be 117½ per cent of 10 per cent, or 11.75 per cent, and the amount of fee actually received by the contractor will be 11.75 per cent of $90,000, or $10,575. In this illustration, $r = 90{,}000/100{,}000\ x\ 100$, and $p = 117\frac{1}{2}$ per cent. In the same case, if the actual cost proves to be $110,000, the percentage fee actually paid to the contractor will be 82½ per cent of 10 per cent, or 8.25 per cent of $110,000 = $9,075. For convenience of reference, the appended table gives the value of "p," the ratio of the actual percentage fee paid to the percentage fee bid, for various values of "r," the ratio of the actual cost to the estimated cost expressed as a percentage.

Ratio of actual cost to estimated cost expressed as percentage.	Ratio of actual percentage fee to percentage fee named in bid expressed as a percentage.	Ratio of actual cost to estimated cost expressed as percentage.	Ratio of actual percentage fee to percentage fee named in bid expressed as a percentage.
140	30	100	100
135	38.75	95	103.75
130	47.5	90	117.5
125	56.25	85	126.25
120	65	80	135
115	73.75	75	143.75
110	82.5	70	152.5
105	91.25	65	161.25
100	100	60	170

142. **Determination of low bidder.**—For the purpose of determining the low bidder, and for this purpose only, the average of the estimated costs submitted by all bidders will be considered as representing the probable actual cost of the work. That bid will be considered low which involves a minimum cost to the Government on the basis of the above assumed actual cost, and the above described sliding scale for determination of contractor's fee, when evaluated for time of completion as per paragraph 165. To illustrate: Assume three bids are received, as follows:

Estimated cost.	Fee (per cent).
(1) $100,000	15
(2) 95,000	16
(3) 150,000	10

Then, the average of the estimated costs is $115,000 and for the purpose of determining the low bidder, $115,000 is considered to represent in each of the above three cases the actual cost of the work. Then, for case (1), on the basis of the sliding scale, the percentage fee to be paid will be 11.1 per cent applied to $115,000. For case (2), the percentage fee to be paid will be 10.1 per cent applied to $115,000. For case (3), the percentage fee to be paid will be 14.1 per cent applied to $115,000. It is evident that case (2) is the low bid, this bid giving a minimum total cost to the Government. In determining the low bidder by this method, the Government will reserve the right to disregard any bid whose estimated cost is considered to vary too widely from the average. In case different dates of completion are given, there would be added to each bid the evaluation factor as explained in paragraph 165.

143. **Adjustment of wages.**—If, after the date of the contract, there shall be any increase in the rates of wages prevailing in the vicinity of a place where work contemplated by the contract is done, that shall necessitate payment by the contractor on account of labor employed exclusively on such work of rates of wages in excess of those prevailing in such vicinity at the date of contract, then the items of labor in the contractor's estimated cost of the work which are affected by such increase in rates of wages shall be correspondingly increased, subject to the limitations prescribed in paragraph 140, and the estimate of cost, as revised thus, shall be used in lieu of the estimate submitted in the bid, in determining the contractor's percentage fee according to the sliding scale: *Provided*, That any increase over wage rates prevailing at the date of the contract before being granted by the contractor shall be notified and approved to in writing by the Bureau of Yards and Docks. For the purpose of this paragraph rates of wages prevailing in the vicinity of a place where work contemplated by the contract is done shall be understood to mean the established rates of wages in the nearest navy yard or station if there is one within 50 miles of such place, or, if there is one within that distance, the rates of wages paid under a well-established wage scale, if any, in such vicinity, or, if there be none, such reasonable rates of wages as may be determined by the Navy Department, Bureau of Yards and Docks. The burden shall be on the contractor of establishing to the complete satisfaction of the Bureau of Yards and Docks, all facts upon which any claim for additional compensation hereunder shall rest, and all questions growing out of any such claim shall be determined by the Navy Department, Bureau of Yards and Docks, whose decision thereof shall be final and conclusive. Determination of such claims shall be deferred until the completion of contract.

144. **Monthly vouchers.**—Receipted bills for material purchased for the work, showing that payment therefor has actually been made by the contractor, shall be submitted monthly to the local officer in charge who will examine the same and if found correct will certify as to their correctness on their face. Such certified bills for all material should accompany monthly vouchers, which shall be forwarded by the officer in charge for payment, to the disbursing office designated as the disbursing office for the contract in question. The officer in charge will also certify to the correctness of all pay rolls for labor applied to the job, and a certified copy of pay rolls concerned in each voucher will accompany same. All bills for material and pay rolls will be given a serial number or other identifying designation, and the pay vouchers shall bear on their face a list of the bills of material and pay rolls which accompany the voucher. Similarly all bills of whatever nature for which payment is made will be certified as correct by the officer in charge and will accompany the pay vouchers. The monthly voucher will cover 30 per cent of the contractor's fee named in his bid. The final voucher prepared after completion of the work shall include any portion of the contractor's fee then due, this fee being in accordance with the sliding scale provided in paragraph 141.

145. **Discrepencies.**—In all cases where the provisions of the "General Provisions Forming Part of the Specifications for Contracts for Public Works, Bureau of Yards and Docks, Navy Department," differ from the specific provisions given in paragraphs 137 to 156, inclusive, the specific provisions referred to shall govern.

146. **Facilities.**—The contractor shall afford sufficient facilities to the authorized representatives of the Government for the inspection of all work, materials, and supplies, and of all accounts, records of cost, etc.

147. **Changes.**—The Government reserves the right to make such changes in the plans and specifications as may be deemed necessary or advisable, and the contractor agrees to proceed with such changes as directed in writing by the Chief of the Bureau of Yards and Docks. The cost of said changes shall be estimated by the officer in charge, and, if less than $500, shall be ascertained by him. If the cost of said changes is $500 or more, as ascertained by the officer in charge, the same shall be ascertained by a board of not less than three officers or other representatives of the Government. The cost of changes, as ascertained above, when approved by the Chief of the Bureau of Yards and Docks, shall be added to or deducted from the contractor's estimate of cost submitted with his bid. This estimate of cost as thus revised shall be used in lieu of the estimate submitted in the bid in determining the contractor's percentage fee, according to the sliding scale.

148. **Purchase of material and employment of labor.**—The officer in charge will approve the purchase of all material for the work previous to the placing of orders therefor by the contractor, such approval to refer especially to the contemplated prices for such material. The interests of the Government will be safeguarded by the officer in charge by ascertaining that the contemplated prices for material are reasonable and that the contractor is purchasing to the best advantage. Similarly, in the employment of all labor under the contract, rates of pay shall be subject to the approval of the officer in charge and only such pay will be authorized by him as is considered fair and equitable, and established as, or comparable with, prevailing rates of wages paid at the yard or station, or in the vicinity where the work is being performed. Rates of pay higher than those established or prevailing in the vicinity at the time of making the contract will not be authorized by the officer in charge except on the approval of the Chief of the Bureau of Yards and Docks. The contractor shall employ on the work no citizens of nations with whom the United States is at war, or of nations allied to or friendly with nations at war with the United States. Furthermore, the officer in charge shall have the right

to demand the immediate removal of any individual from the work, and where such demand is made, the individual referred to shall be removed from the work and not again employed thereon. This right of removal shall apply to all work done by the contractor, whether on the site or elsewhere.

149. **Eight-hour law.**—The contractor shall have the right, under the contract, to employ labor in excess of eight hours per day, in view of the present emergency conditions, such employment in excess of eight hours, however, to be paid for at the rate of not less than time and half time.

150. **Discounts.**—The contractor shall take advantage of all the discounts available, and the cost to the Government shall be based upon the actual net cost to the contractor after the deduction of such discounts.

151. **Fire insurance.**—The contractor will protect against fire loss his own interests as distinct from risks on materials purchased and work performed and paid for by the Government. The cost of any fire insurance taken out by the contractor shall be considered as part of the cost of the work, as provided in paragraph 138, provided such insurance is approved by the officer in charge of the work.

152. **Control.**—The contractor shall have full control, under the direction of the officer in charge, of all labor employed on the work and, subject to the provisions of this addendum, shall have power to employ or discharge such labor as the contractor may deem necessary to the economical and efficient prosecution of the work, provided, however, that the rates of pay of such labor shall be subject to the approval of the officer in charge.

153. **Subcontracts.**—Previous to entry into any subcontract for any portion of the work, the contractor shall secure proposals for the work in question and submit same to the officer in charge for his approval. Upon approval by the officer in charge, the contractor shall prepare agreements with the subcontractors and superintend the furnishing of all labor and material as may be required by the said agreements.

154. **Cancellation of contract.**—Should the services rendered or work performed by the contractor prove at any time unsatisfactory to the Government, either because of insufficient diligence in the prosecution of the work, or on account of excessive cost of the work, or other reason, the Government shall be at liberty after giving 10 days' written notice to the contractor, to terminate the contract, and in that event the Government shall pay to the contractor the cost of the work up to such date not already paid for, plus 30 per cent of the percentage fee bid upon by the contractor, such payment of 30 per cent to constitute full compensation to the contractor. Upon such payments being made by the Government to the contractor, the contract shall be terminated.

155. **Bond.**—The contractor shall furnish a bond in a penal sum of 5 per cent of the estimated total cost of the work, guaranteeing the faithful performance of the contract and the prompt payment to all persons supplying labor and material in the prosecution of the work. If the above bond shall involve any cost, such cost shall be borne by the contractor and no part of the cost of the bond shall be included as a part of the cost of the work. A personal surety bond will be accepted, provided the same is furnished by two satisfactory individual sureties.

156. **Bidder's ability.**—No bid will be considered from any bidder who has not had experience in the construction of marine railways, or in special water front construction of similar character. Each bidder shall submit a list of the work of this character which has been performed by him, giving locations, character, cost, date of completion, etc. Each bidder will also be required to name the superintendent or foreman whom he expects to employ on this work, giving a statement of this superintendent's experience for the last 10 years, including the character of the work performed by him, length of time employed by the bidder, and otherwise full and complete information which will enable the Government to judge of the superintendent's suitability for this work.

PROPOSALS.

157. **Note.—The bureau will take no cognizance of errors in the making up of estimates which are called to its attention after the opening of proposals.**

158. **Certified check and bond.**—Each proposal must be accompanied by a certified check, payable to the Chief of the Bureau of Yards and Docks for the sum of $3,500 for each marine railway, as a guaranty that the bidder will not, without cause, approved by the Chief of the Bureau of Yards and Docks, withdraw his bid, and that if awarded to him, he will execute the required contract within 10 days after its delivery to him for that purpose and give a bond (preferably that of a first-class surety company) in a penal sum equal to 30 per cent of the contract price, conditioned upon the faithful performance of the contract. This bond is not required with the proposal. Checks of unsuccessful bidders will be returned immediately after the contract is awarded, and of the successful bidder upon the execution of the contract.

159. **Form of proposals.**—Proposals and all exhibits, alternative plans, letters of explanation, circulars, and all other papers (except the certified check) which it is desired to have considered in connection therewith must be made in duplicate. Government drawings and specifications should not be inclosed with the proposal. Drawings and specifications, in possession of unsuccessful bidders, shall be returned to the bureau immediately after the contract is awarded. Bidders are expected to read the specification with special care and to observe all of its requirements. Except in so far as proposals shall, under a special heading for the purpose, call attention to every particular wherein same conflicts with the requirements of the specifications, the latter shall govern and be complied with to the satisfaction of the Chief of the Bureau of Yards and Docks at the expense of the contractor.

Item 1.—Lump sum price and time of completion for two marine railways—one at Boston, Mass., and one at Charleston, S. C., complete, in accordance with the drawings and specifications.

Item 2.—Lump sum price and time of completion for one marine railway at Boston, Mass., complete, in accordance with the drawings and specifications.

Item 3.—Lump sum price and time of completion for one marine railway at Charleston, S. C., complete, in accordance with the drawings and specifications.

Item 4.—Estimate of cost, percentage fee, and time of completion for two marine railways—one at Boston, Mass., and one at Charleston, S. C., complete, in accordance with the drawings and specifications. (See pars. 137 to 156, inclusive.)

Item 5.—Estimate of cost, percentage fee, and time of completion for one marine railway at Boston, Mass., complete, in accordance with the drawings and specifications. (See pars. 137 to 156, inclusive.)

Item 6.—Estimate of cost, percentage fee, and time of completion for one marine railway at Charleston, S. C., complete, in accordance with the drawings and specifications. (See pars. 137 to 156, inclusive.)

Item 7.—Net price per linear foot of increase in length of piles for work at the navy yard, Boston, Mass., which may be required of lengths greater than those called for in paragraph 39. The increased length to be

paid for will be the difference between the elevation of points as given in paragraph 39 and the elevation of points as actually driven.

	Price per linear foot of increase in length of piles.				
	Bents 1 to 40.	Bents 41 to 70.	Bents 71 to 130.	Bents 131 to 170.	Bents 171 to 196.
Increase to be not greater than 10 feet					
Increase to be not greater than 15 feet					
Increase to be not greater than 20 feet					

Item 8.—Net price per linear foot of increase in length of piles for work at the navy yard, Charleston, S. C., which may be required of lengths greater than those called for in paragraph 39. The increased length to be paid for will be the difference between the elevation of points as given in paragraph 39 and the elevation of points as actually driven.

	Price per linear foot of increase in length of piles.		
	Bents 1 to 30.	Bents 31 to 150.	Bents 151 to 216.
Increase to be not greater than 10 feet			
Increase to be not greater than 15 feet			
Increase to be not greater than 20 feet			

160. **Bidder's ability.**—Before he is awarded the contract any bidder may be required to show that he has the necessary capital, facilities, experience, and ability to begin the work promptly and perform it in a satisfactory manner, and that he is regularly engaged in the business of performing such work.

161. **Bidders shall submit information with their proposals as follows:** Name and address of manufacturers of the electrically driven hoist, chains, and electrical equipment. Each piece must be plainly stamped with the name of the bidder, or otherwise marked to indicate the bid to which it belongs. Should the bidder fail to name the articles mentioned, the Government reserves the right to name the articles to be furnished, subject to specification requirements. See paragraphs Nos. 95 and 126.

162. **Base price for steel.**—For purposes of comparison, bidders shall state in their proposals the base prices for structural steel, f. o. b. Pittsburgh basis, on plain plates and shapes, on which their prices have been figured, stating also the estimated weights, respectively, of plates, shapes, and reinforcing bars, and the mills from which these plain materials would ordinarily be secured. Bidders shall also state the name of the concern from which they have secured their quotation on such steel.

163. **Examination of site.**—Intending bidders are expected to examine the site of the proposed work and inform themselves thoroughly of the actual conditions and requirements before submitting proposals. Attention is directed to the conditions and subsurface construction of the abandoned ways at Boston, a portion of which will be removed for the new work.

164. **Eight-hour law.**—The contractor will have the right, under the contract, to employ labor in excess of eight hours per day, in view of the present emergency conditions; such employment in excess of eight hours, however, shall be paid for at the rate of not less than time and one-half time. Attention of bidders is directed to the Executive order dated March 22, 1917, which authorizes suspension of the limitation of eight hours' work on Government contracts.

165. **Evaluation of bids.**—The attention of bidders is directed to paragraph 10 of the "General Provisions," relative to the evaluation of bids.

166. **Acceptance and rejection of proposals.**—The Government reserves the right to accept any bid, to waive any defects and informalities in the proposals, and to reject any or all bids.

167. **Proprietary articles.**—Where proprietary articles are mentioned herein, bidders may base their proposals upon similar articles of equal value and efficiency, but the fact that they have done so must be stated therein, and in all cases when not so stated such articles may be installed only with the approval of the officer in charge.

168. **Information.**—For any further information needed by intending bidders, application should be made to the Chief of the Bureau of Yards and Docks or to the Commandants, Navy Yard, Charleston, S. C., and Boston, Mass. Any discrepancies or omissions noted by intending bidders in drawings or specifications should be promptly referred to the Chief of the Bureau of Yards and Docks, Navy Department, Washington, D. C., for correction or interpretation before the opening of bids.

NAVY DEPARTMENT,
Bureau of Yards and Docks, February 14, 1918.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1918

APPENDIX B

"Marine Railway No. 11 Operating Instructions."
July 16, 1962

16 July 1962

BOSTON NAVAL SHIPYARD

MARINE RAILWAY NO. 11

OPERATING INSTRUCTIONS

A. Starting (From Secured Condition)

1. Open headhouse.
2. Close recording wattmeter safety switch on back wall and start wattmeter operating.
3. Open oil feeds at bearings, see that all oil reservoirs are filled.
4. Check to see that the controller is at zero.
5. Close the 2300V. Disconnecting Switches.
6. Close the 2300V. Oil Circuit Breaker.
7. Lift the main pawl latch or keeper.
8. Release the main pawl by giving a slight upward movement to the controller handle and bringing it back immediately to zero.
9. Lift the main pawl with lever provided and pin lever to hold pawl clear.

The hauling machine is now ready to operate the cradle.

B. To Lower the Cradle

1. Note the positions of the inshore ends of roller nests; if any of the ends are more than one roller nest length down the incline when the cradle is in the up position special care must be exercised when backing the cradle beyond the outer limit (320 feet of travel) and when approaching the extreme outer limit (340 feet); in such a case, backing must not be beyond a point where roller nests overhang the track by more than four feet. This limit can only be determined by a diver's observation. Exceeding this limit could result in the damage of roller nests or main railway trackage, or both.

   The above critical condition should be foreseen and prevented by detaching the outermost roller nest and attaching it at the inshore end of the roller nests.

2. Turn the controller handle in the downward direction in a continuous movement until it is on the last point.

   Note: The controller should not be held on any intermediate point since such action would permit the load to over-speed the motor. The controller should be at the last point by the time the motor is at full speed; thus, the motor will act itself to control the speed.

C. To Stop the Hauling Machine

1. Place controller handle at zero.

D. To Haul the Cradle

1. Turn the controller handle in the up direction gradually from point to point until at full speed.

E. To Secure

1. Lower the main pawl (it may be necessary to inch the large gear slightly to secure full engagement against the gear tooth).
2. Set the main pawl latch or keeper.
3. Apply the hydraulic emergency brake, place keeper blocks at brake drum and leave brake on.
4. Close oil feeds to bearings, leave reservoirs full.
5. Open 2300V. Oil Circuit Breaker.
6. Open 2300V. Disconnecting Switches.
   a. Block contactors with wedges provided.
7. Shut off recording wattmeter and open safety switch on back wall.
8. Sign recording wattmeter, write in ship numbers, date, up and down notations, sign log sheets on oil circuit breaker stand.
9. Secure headhouse.

F. Notes

1. Motor Load

The high speed gear ratio may be used to haul the cradle when it is empty. The high speed gear ratio may also be used to haul a vessel on the cradle provided the full load rating of 595 amperes on the motor is not exceeded. Should the full load be arrived at during a hauling operation the cradle should be stopped, the Docking Officer notified, brakes and pawl set and gear ratio changed to low. The cradle should always be lowered using the same gear ratio that was used on the previous haul.

2. Emergency Brake

Hydraulic pressure should be maintained at 1800 p.s.i. To release brake, remove wooden blocks at brake drum; close left hand valve at hydraulic cylinder and open right hand valve. To apply brake, close right hand valve and open left hand valve; place wooden blocks outside of drum to maintain brake security.

440

AUG 2 4 1962

MEMORANDUM

From: Public Works Officer
To: Docking Officer

Subj: Addendum to "Boston Naval Shipyard Marine Railway No. 11 Operating Instructions" of 16 July 1962

1. Add at the end under "F. Notes":

"3. Greasing

a. Equaliser gears should be greased via the tubes terminated by alemite fittings under the trap door in the main deck above the equaliser sheaves. This should be scheduled before each docking or every 90 days if no docking occurs.

b. Chain should be greased before its passage over the wildcat hauling machinery."

M. R. NELSON
By direction

Copy to:
Code 440
442
450
457
D.P. 2927 (Code 440)

BIBLIOGRAPHY

Manuscript Materials

Charlestown Navy Yard, Boston National Historical Park, Boston, Massachusetts, Archives and Maintenance Files.

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

Books

Cunningham, Brysson. A Treatise on the Principles and Practice of Dock Engineering, Vol. 1. London: Chas: Griffin, 1904.

Colson, Charles. Notes on Docks and Dock Construction. London: Longmans Green & Co., 1894.

Du Plat-Taylor, F.M. The Design, Construction and Maintenance of Docks, Wharves and Piers. London: Ernest Benn Ltd, 1928.

Greene, Carlton. Wharves and Piers, Their Design, Construction and Equipment. New York: McGraw-Hill, 1917.

ILLUSTRATION 1

"Navy Yard Boston, Site of Marine Railway from N. W., July 5, 1918." Photograph taken by Crandall Construction Company. Courtesy of Boston National Historical Park, National Park Service.

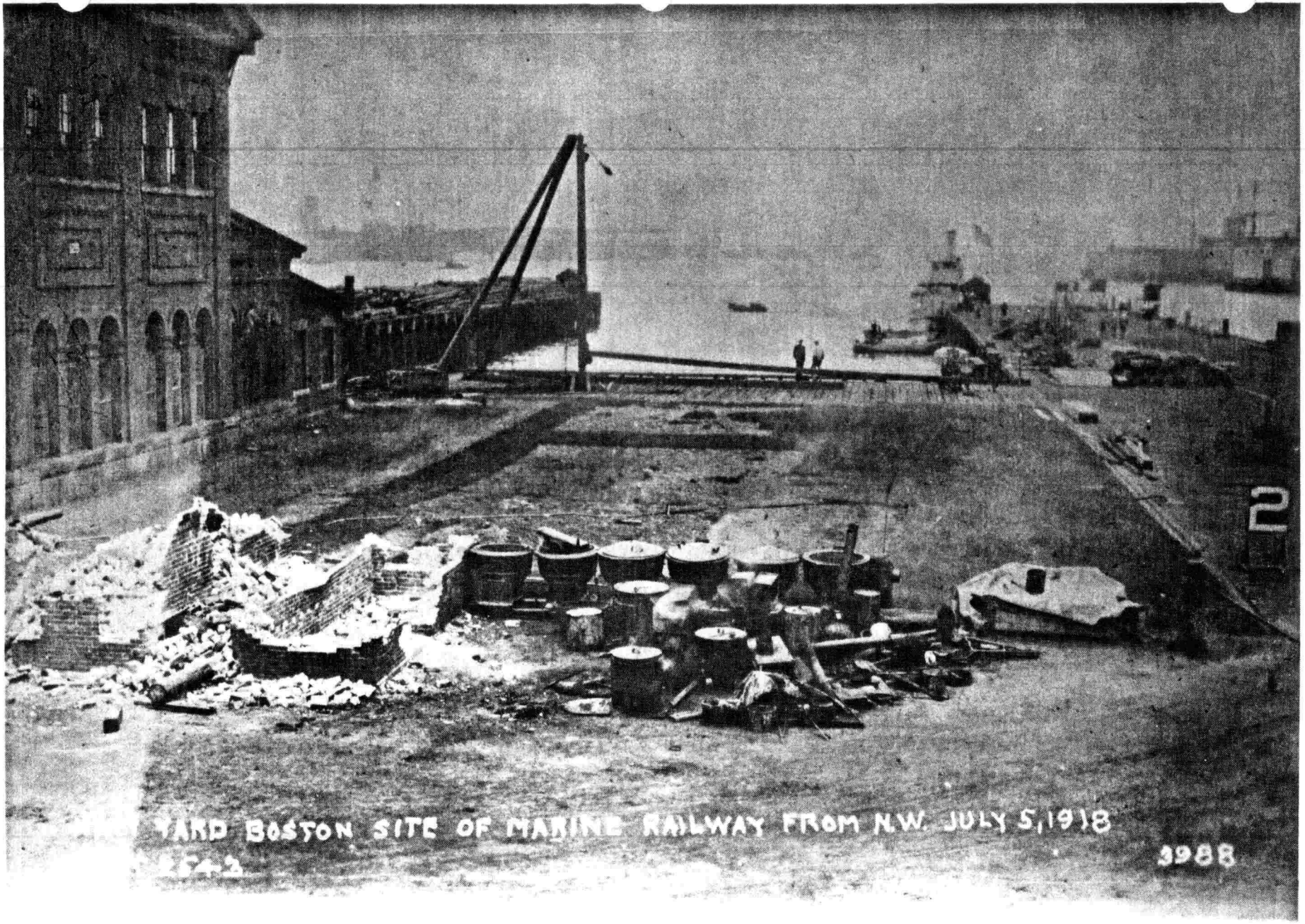

2
YARD BOSTON SITE OF MARINE RAILWAY FROM N.W. JULY 5, 1918
3988

ILLUSTRATION 2

"Navy Yard Boston, Marine Railway, Cont. 2843, December 3, 1918, From S. W."

Photograph taken by Crandall Construction Company. Courtesy of Boston National Historical Park, National Park Service.

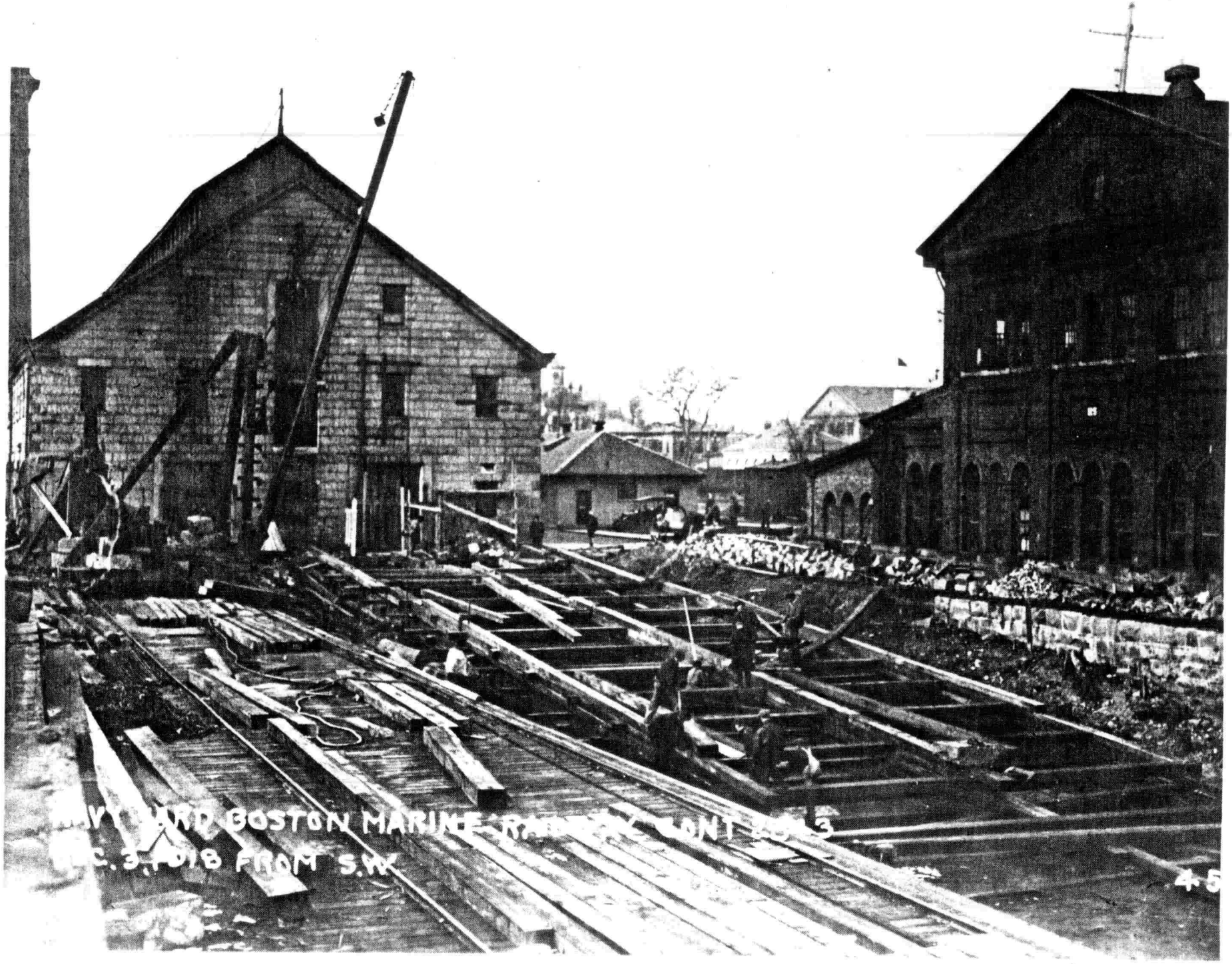

DEC. 3, 1918 FROM S.W.
4.5

ILLUSTRATION 3

"Navy Yard Boston, Marine Railway, Cont. 2843, March 9, 1919 from N.W."

Photograph taken by Crandall Construction Company. Courtesy of Boston National Historical Park, National Park Service.

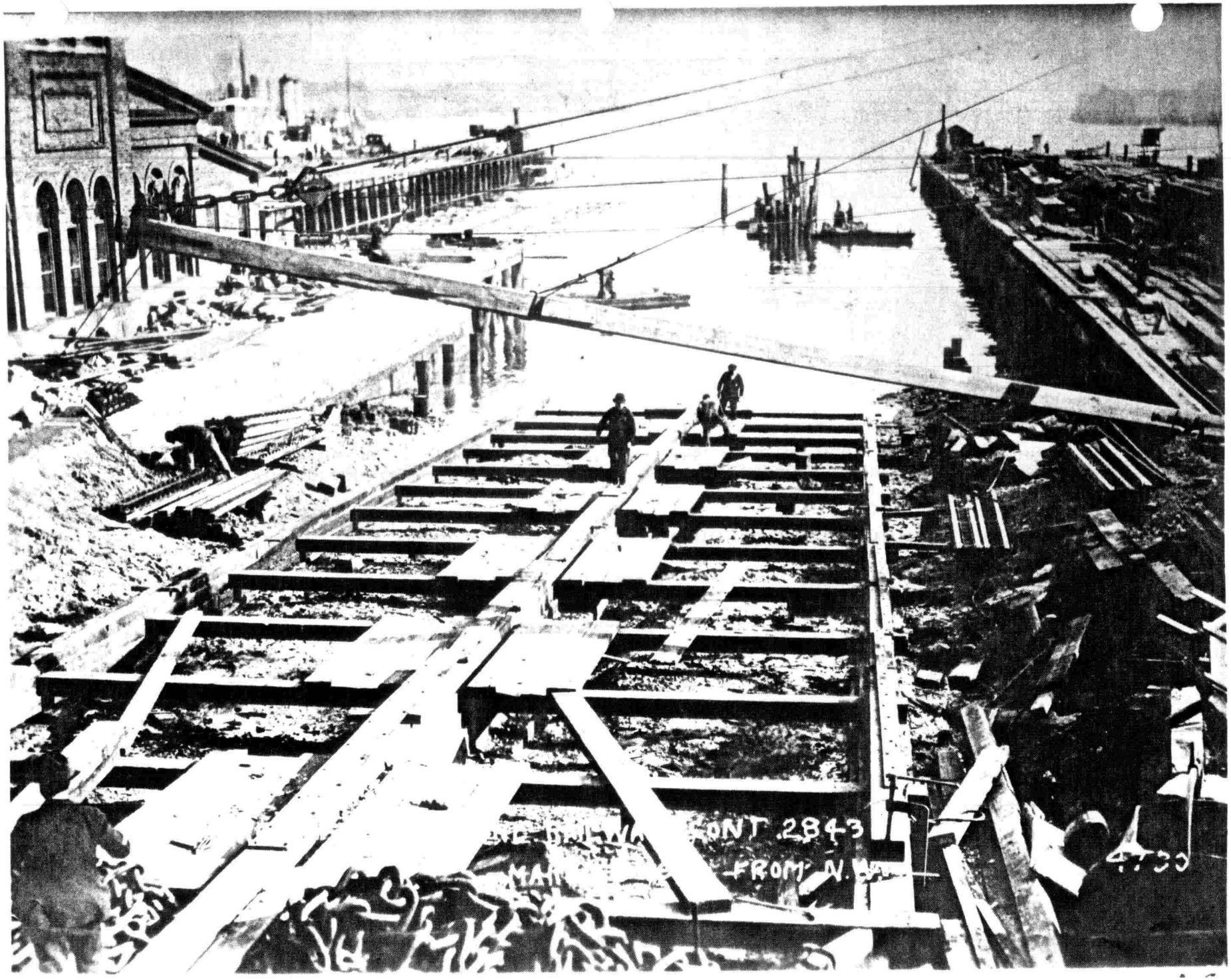

ONT. 2843
FROM N.W.
4.33

ILLUSTRATION 4

"Navy Yard Boston, Marine Railway Cont. 2843, From N.W., May 5, 1919."

Photograph taken by Crandall Construction Company. Courtesy of Boston National Historical Park, National Park Service.


NAVY YARD BOSTON MARINE RAILWAY CONT 2843
FROM N.Y. YARD 1919

ILLUSTRATION 5

"Navy Yard Boston, Test of Marine Railway, Cont. 2843, Cradle at Limit of Ways, May 29, 1919."

Photograph taken by Crandall Construction Company. Courtesy of Boston National Historical Park, National Park Service.

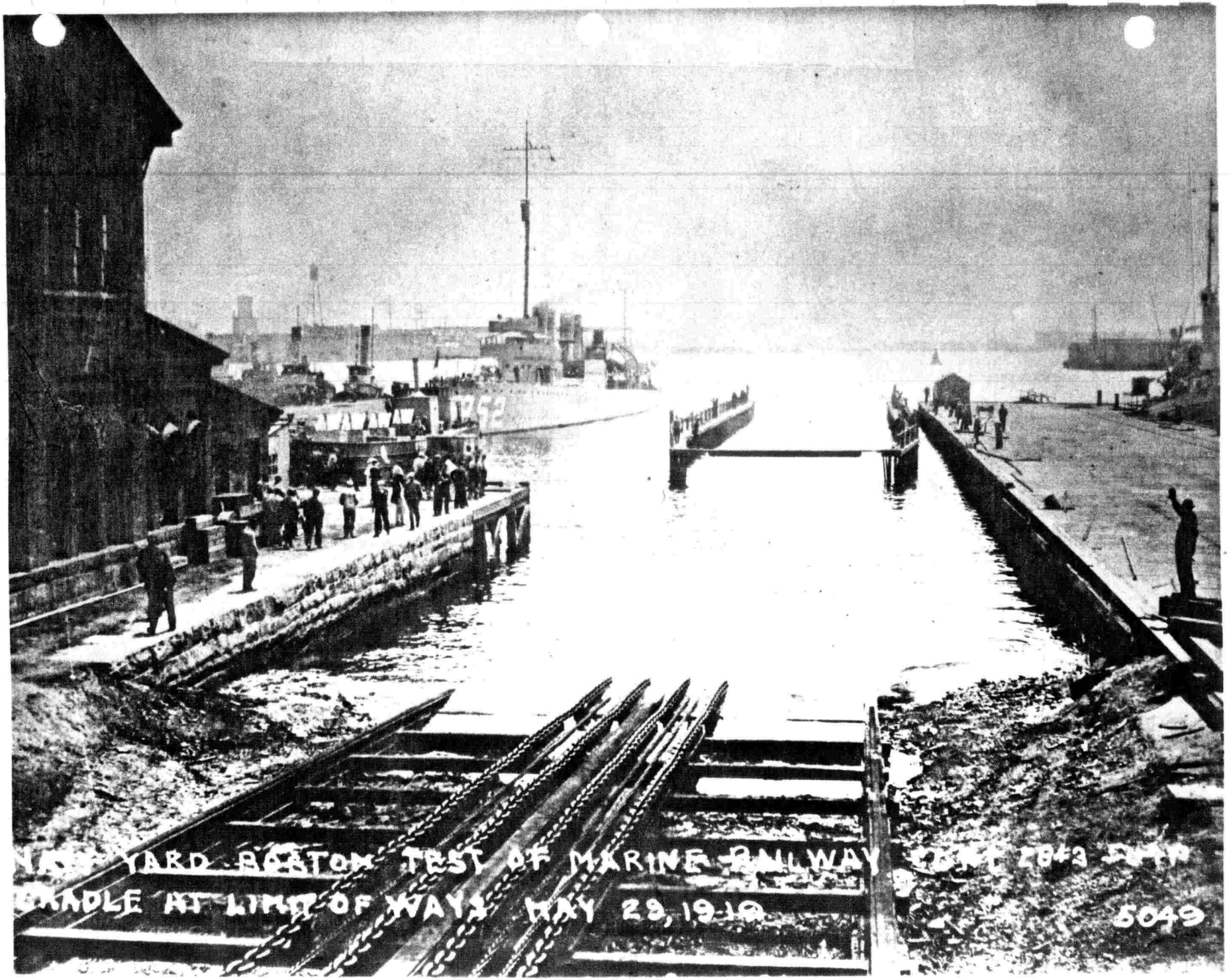

NAVY YARD BOSTON TEST OF MARINE RAILWAY
CRADLE AT LIMIT OF WAY MAY 28, 1910
5049

ILLUSTRATION 6

"U. S. Navy Yard Boston, Test of Marine Railway, Cont. 2843, U.S.C.G. Ossippee in Cradle after Raising. June 2, 1919."

Photograph taken by Crandall Construction Company. Courtesy of Boston National Historical Park, National Park Service.

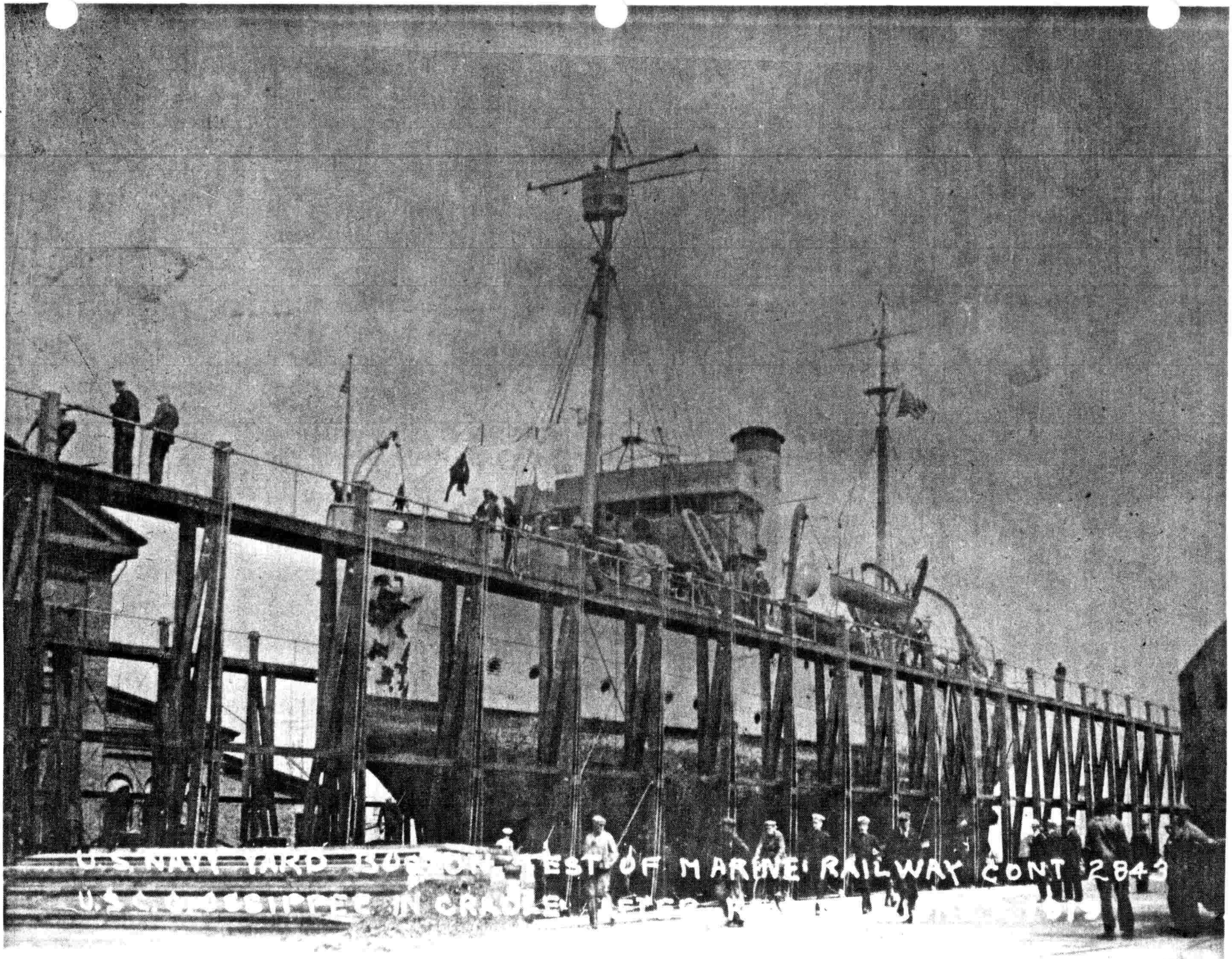

U.S. NAVY YARD
TEST OF MARINE RAILWAY CONT 2843
U.S.C.G.
IN CRADLE

ILLUSTRATION 7

"Navy Yard Boston, Test of Marine Railway, Cont. 2843, Cradle Out With U.S.S. Grebe & U.S.S. Acushnet, June 10, 1919." From north.

Photograph taken by Crandall Construction Company. Courtesy of Boston National Historical Park, National Park Service.

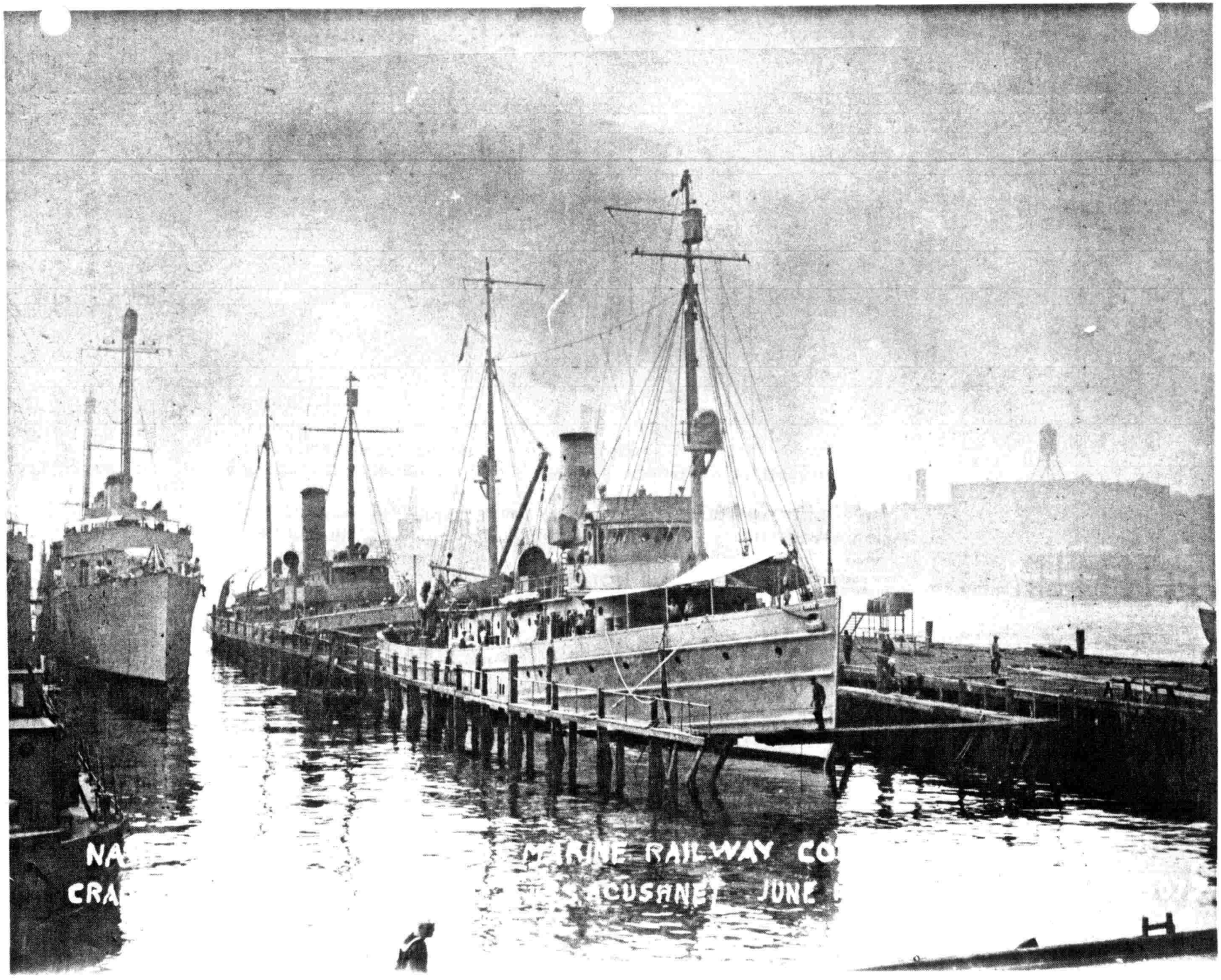

NA
CRA
MARINE RAILWAY CO
SYDNEY JUNE

ILLUSTRATION 8

Hauling Machinery for Marine Railway No. 11, Southeast Corner of Building 24, Charlestown Navy Yard. Undated.

Photograph taken by U. S. Navy. Courtesy of Boston National Historical Park, National Park Service.

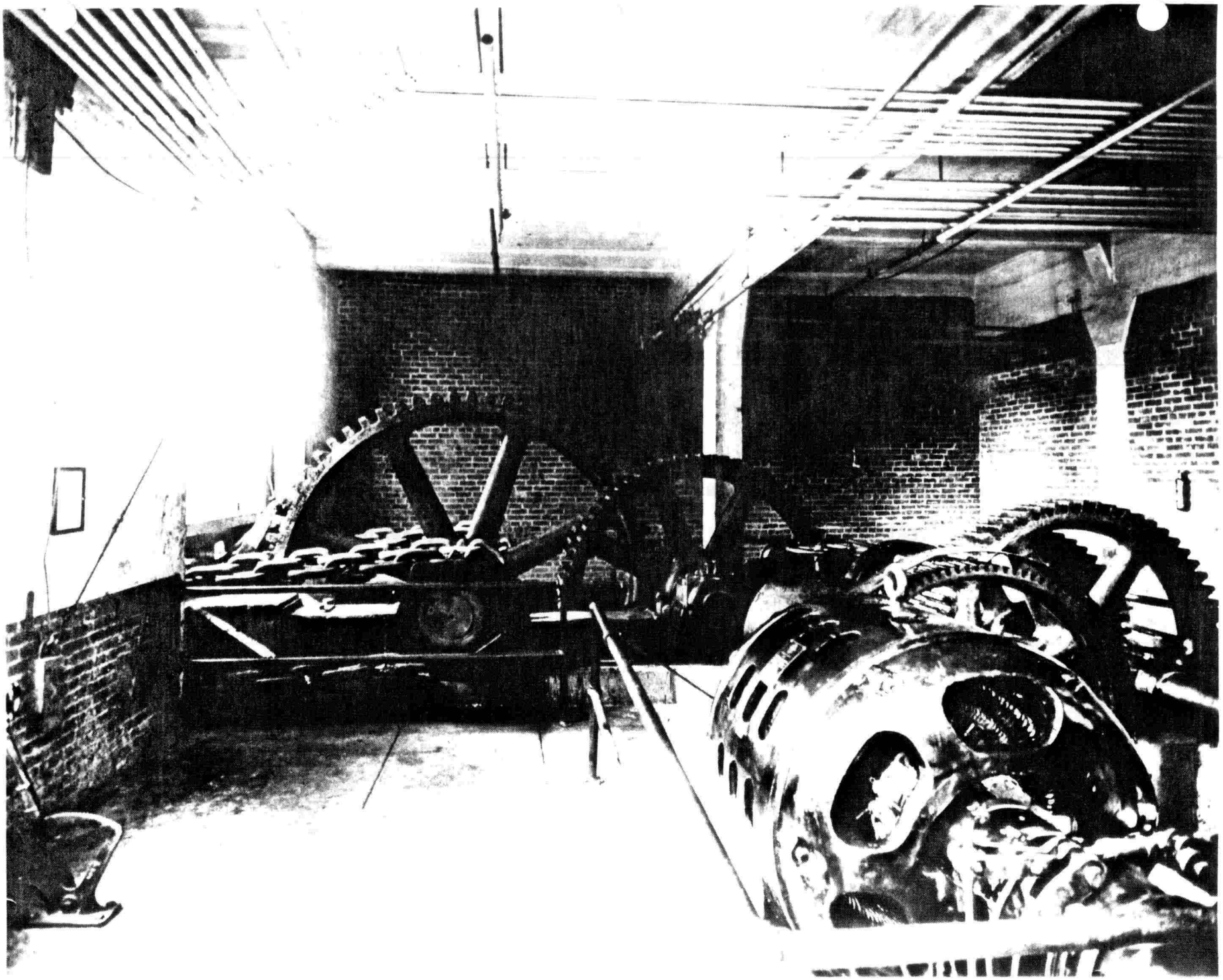


ILLUSTRATION 9

Marine Railway No. 11 Charlestown Navy Yard, June 13, 1931.

Photograph taken by U. S. Navy. Courtesy of Boston National Historical Park, National Park Service.

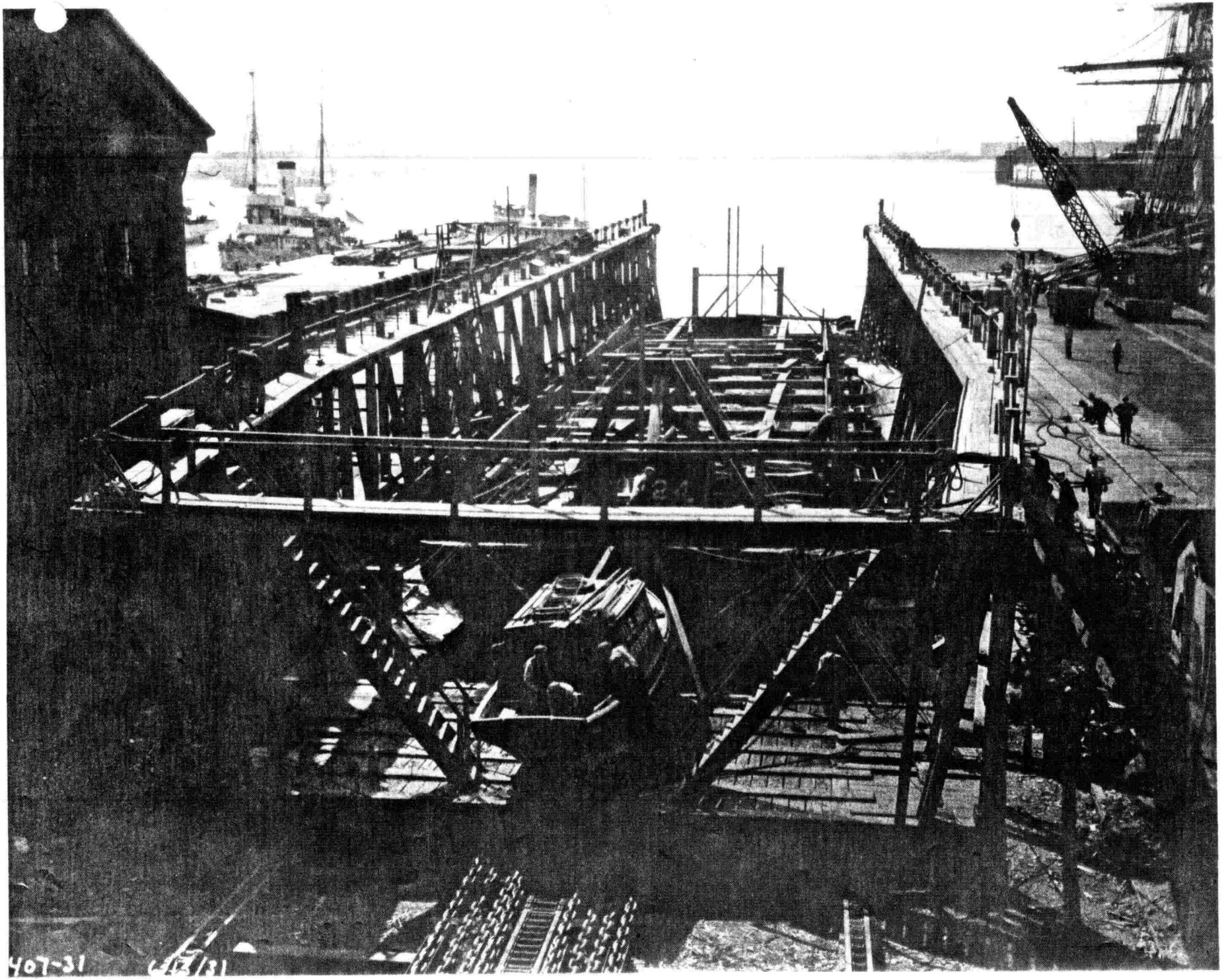

407-31

ILLUSTRATION 10

Marine Railway No. 11, Charlestown Navy Yard, February 1935.

Photograph taken by U. S. Navy. Courtesy of Boston National Historical Park, National Park Service.

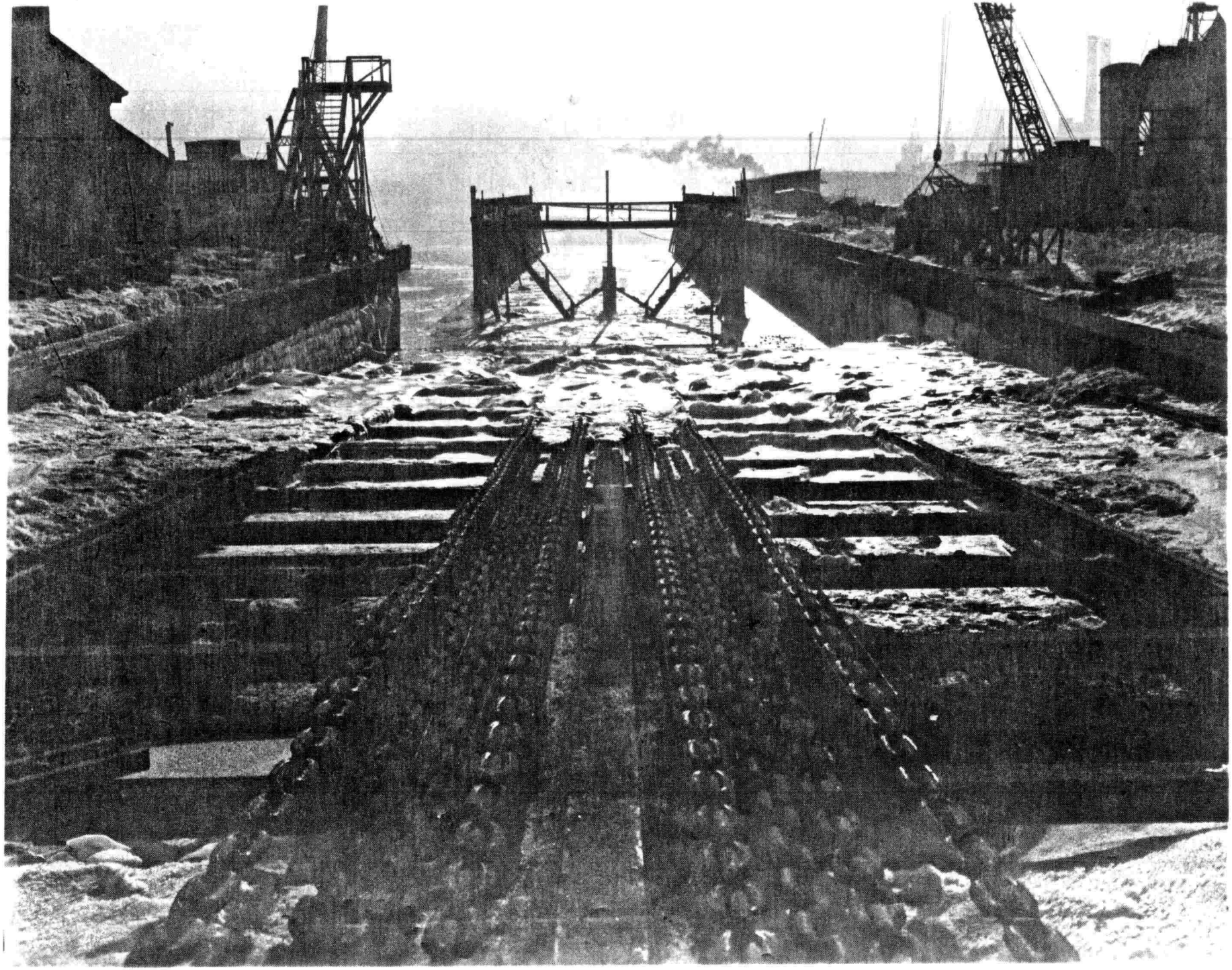


ILLUSTRATION 11

Entering the Cradle of the Marine Railway, Submarine USS Torsk (SS-423).

Photograph published in Boston Naval Shipyard News, February 23, 1968. Courtesy of Boston National Historical Park, National Park Service.

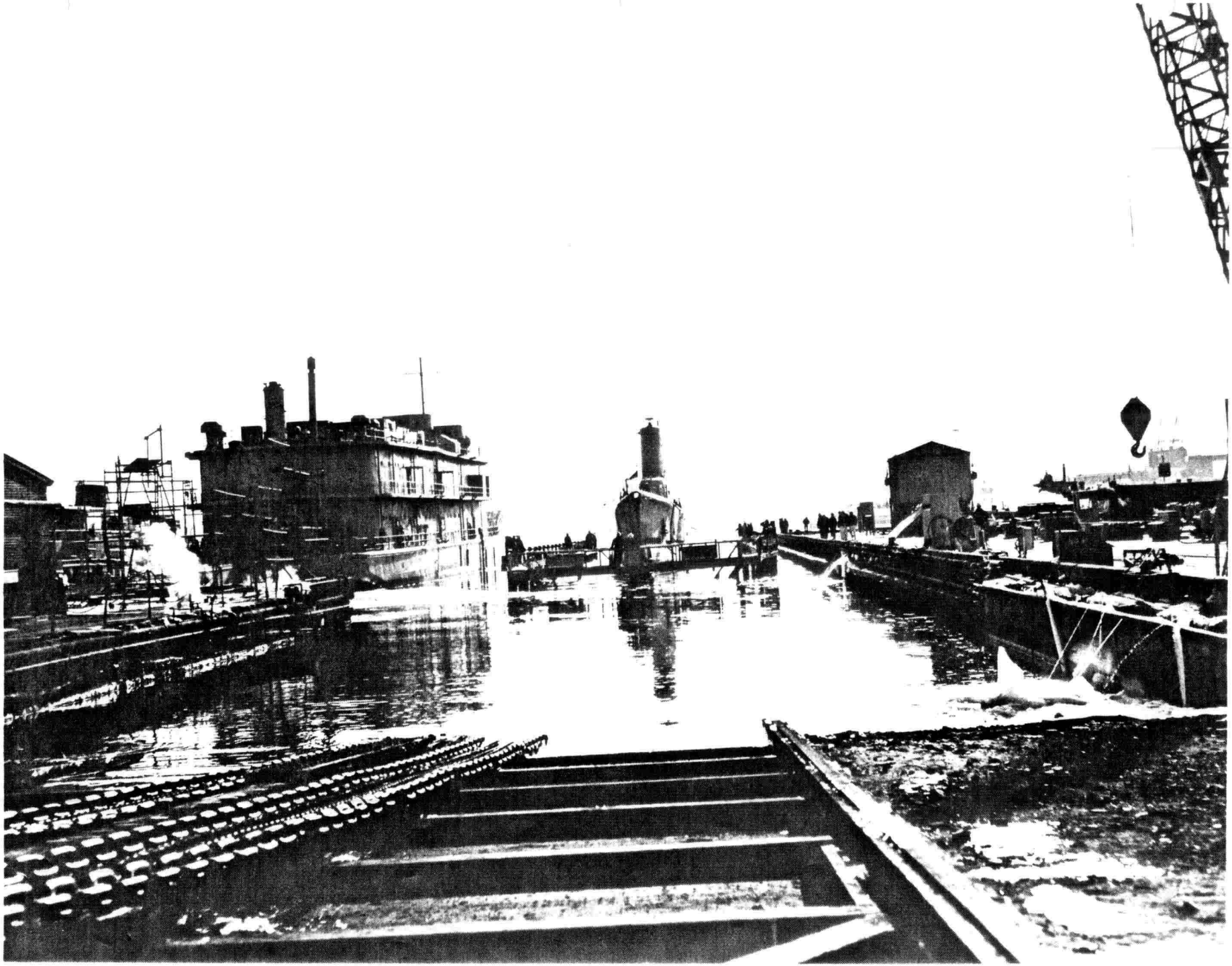


ILLUSTRATION 12

Submarine USS Torsk in Marine Railway Cradle.

Photograph published in Boston Navy Shipyard News, February 23, 1968. Courtesy of Boston National Historical Park, National Park Service.

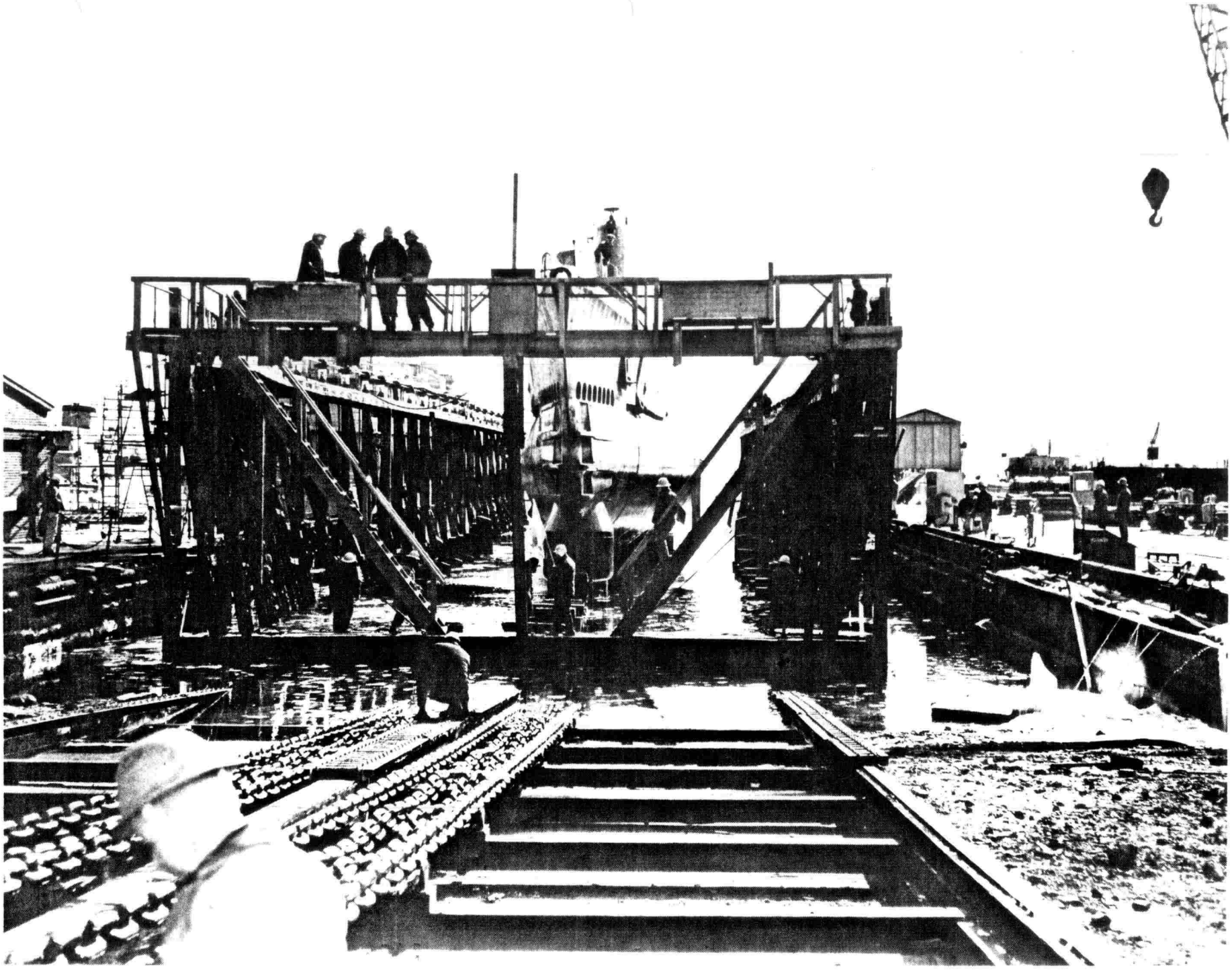


ILLUSTRATION 13

Marine Railway, Charlestown Navy Yard, Boston National Historical Park. View from outboard end of Pier 2.

Photograph taken by author, 1979.

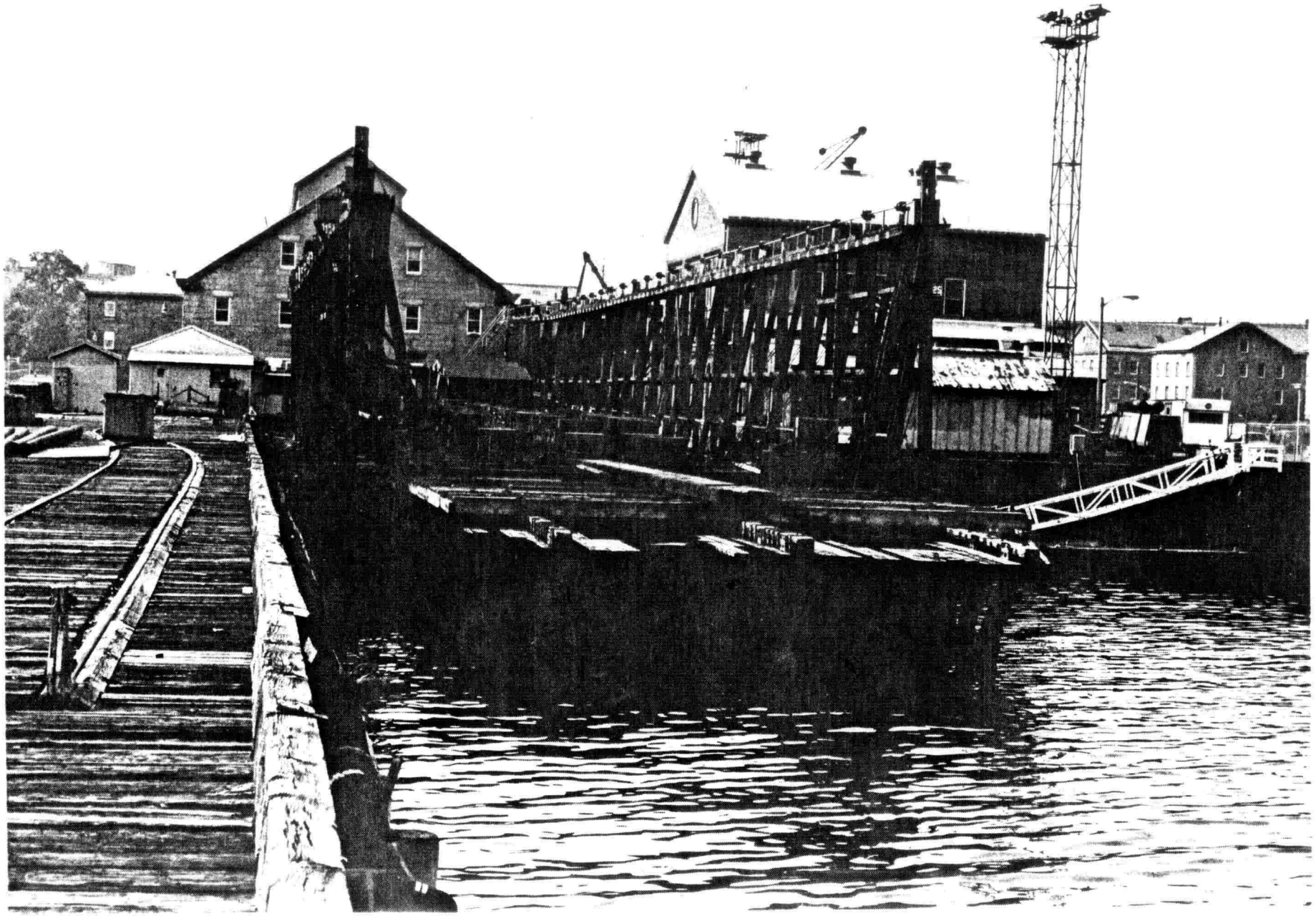


ILLUSTRATION 14

Marine Railway, Charlestown Navy Yard, Boston National Historical Park.

Photograph taken by author, 1979.

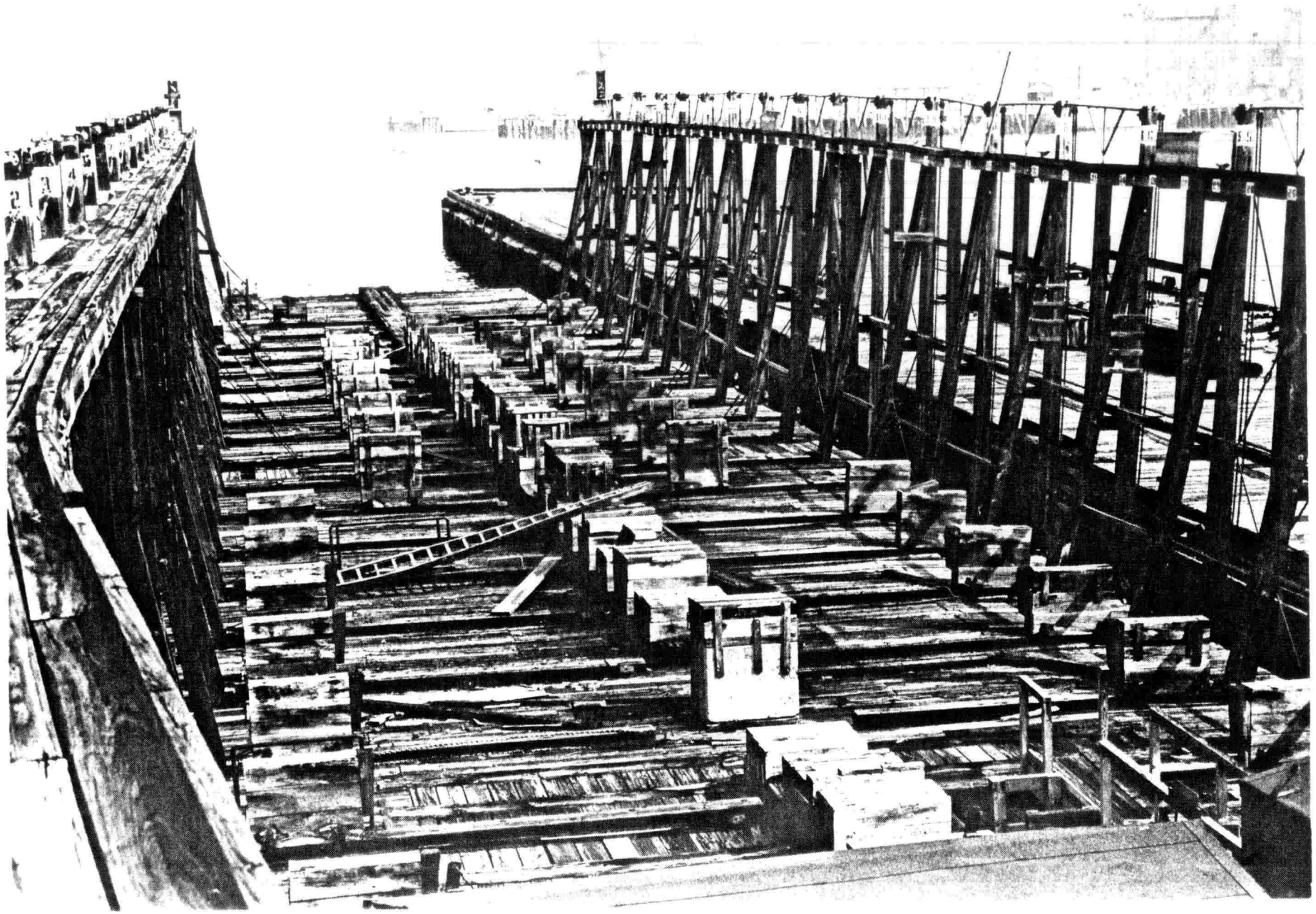


ILLUSTRATION 15

Movable Bilge Blocks and Deck of Marine Railway Cradle, Charlestown Navy Yard, Boston National Historical Park.

Photograph taken by author, 1979.

ILLUSTRATION 16

Stone ballast in ballast locker seen through hole in Marine Railway cradle decking, Charlestown Navy Yard, Boston National Historical Park.

Photograph taken by author, 1979.

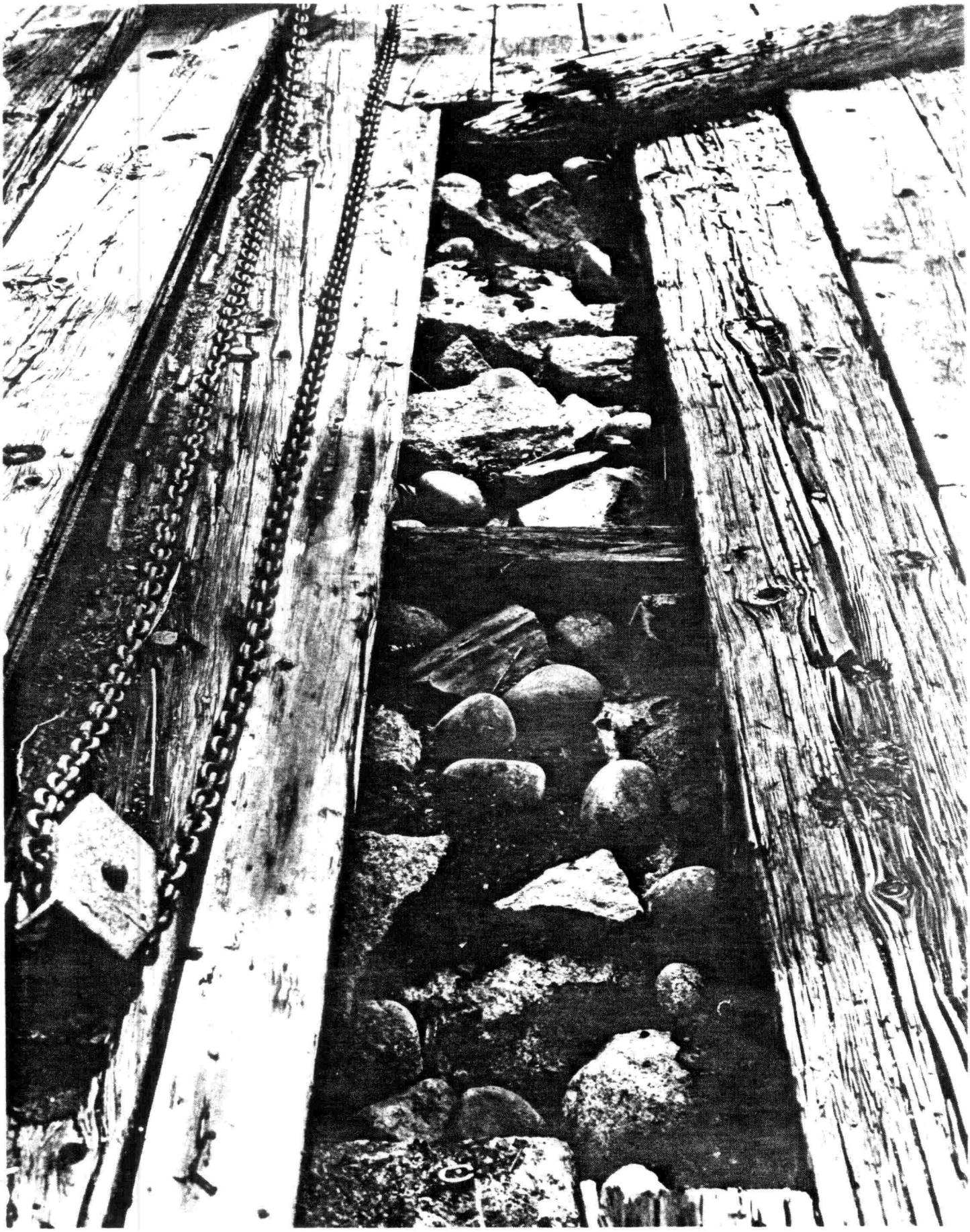
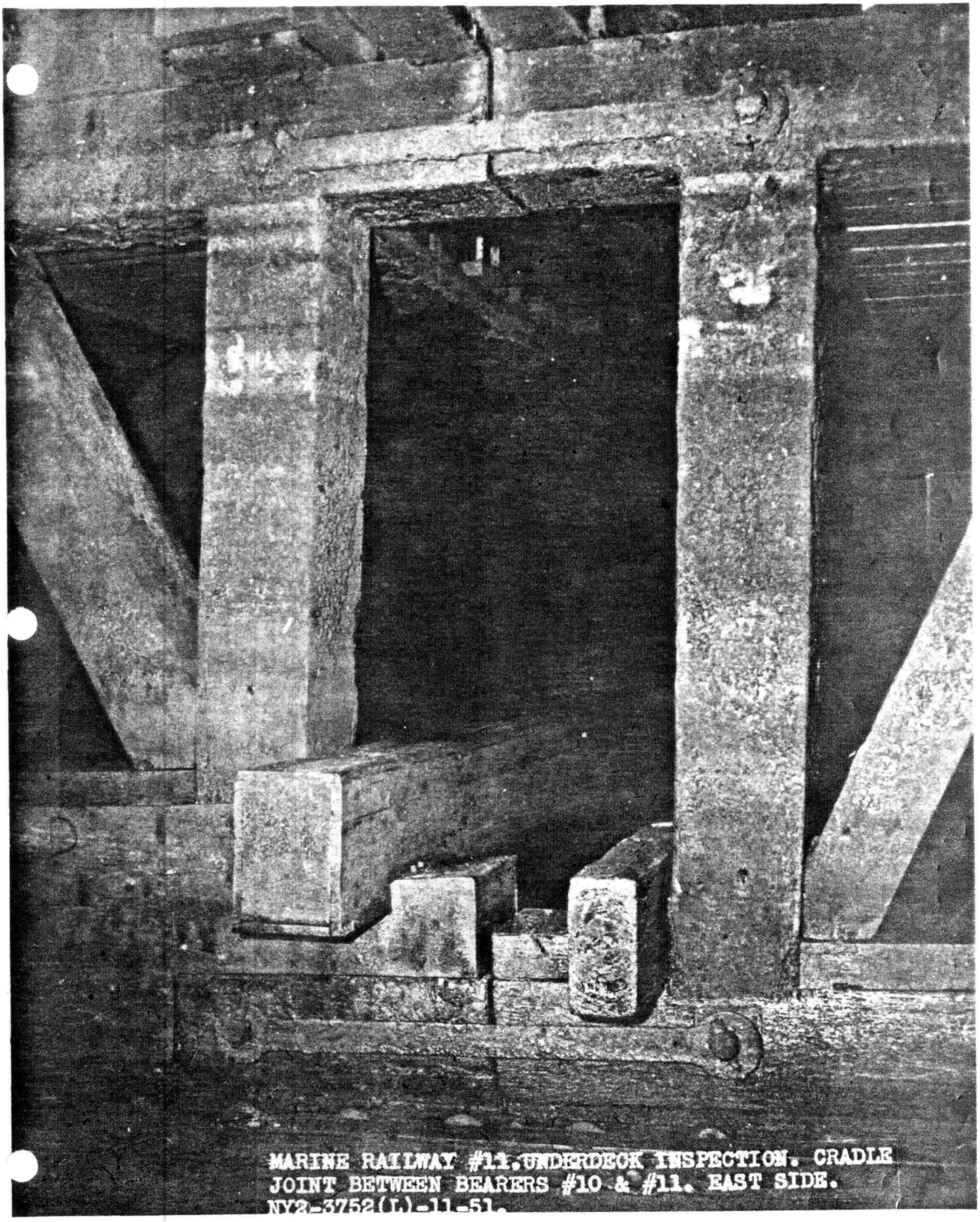


ILLUSTRATION 17

"Marine Railway #11. Underdeck Inspection. Cradle Joint Inspection Between Bearers #10 & #11. East Side," 1951.

Photograph taken by U. S. Navy. Courtesy of Boston National Historical Park, National Park Service.

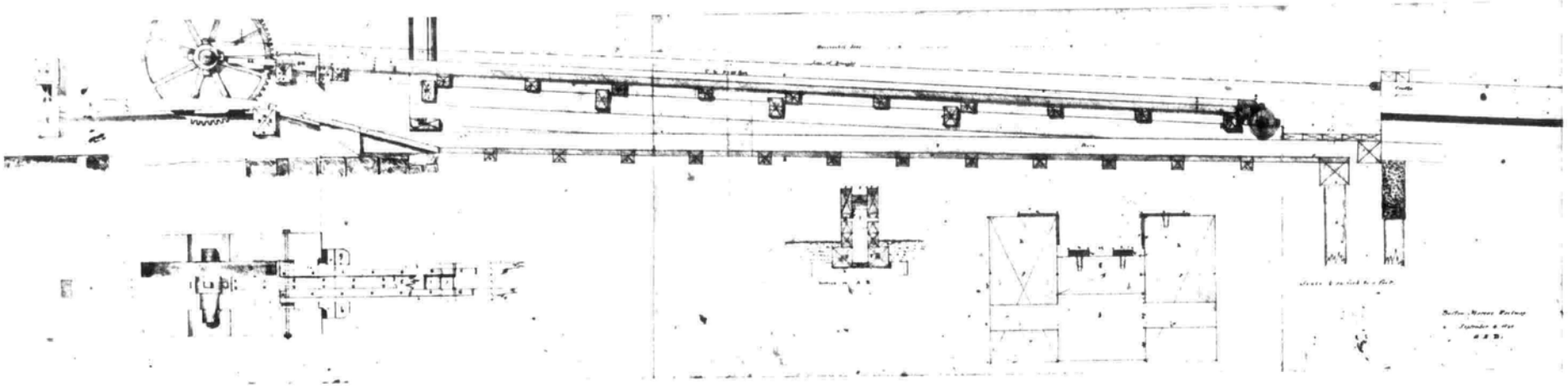


MARINE RAILWAY #11, UNDERDECK INSPECTION. CRADLE JOINT BETWEEN BEARERS #10 & #11. EAST SIDE.
NY2-3752(L)-11-51.

ILLUSTRATION 18

"Boston Marine Railway, September 4, 1840." Signed G.R.B. Drawing by George Rumford Baldwin.

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



As the nation's principal conservation agency, the Department of the Interior has basic responsibilities to protect and conserve our land and water, energy and minerals, fish and wildlife, parks and recreation areas, and to ensure the wise use of all these resources. The department also has major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

Publication services were provided by the graphics staff of the Denver Service Center. NPS 1879