Kurtz, Corps of Engineers, who reported it at that time as practically useless, from the decay of the wooden structures and the accumulations of mud due to the close lines of piles that obstructed the currents. Experience has shown that close structures are not necessary to the formation of an ice harbor, and are to be avoided as inevitably causing deposits.

The obstacle to the movement of ice created by detached piers and the closely packed vessels is sufficient to check its flow, while by the increased velocity of the water, due to the same cause, the important feature of depth is maintained unimpaired. Colonel Kurtz's estimate for restoring this harbor was $190,000, assuming that a portion of the existing structures would be serviceable for several years. This is now no longer the case, and the estimate must be increased.

In 1873 an act was passed by the general assembly of the State of Delaware ceding 50 acres on the north end of Reedy Island, and also the ice harbor itself, to the United States. The ceded area was surveyed in 1874, and the southern limit marked with boundary posts of stone.

During the fiscal year urgent representations have been made by the shippers and vessel owners of this port of the great and increasing necessity of an ice harbor in this vicinity, some urging its re-establishment on the same site, others suggesting other points in the vicinity as possessing greater advantages.

Vessels arriving from sea in winter are liable to encounter at this point heavy drifting ice, in conflict with which no skill in navigation will avail to overcome the danger of prolonging the journey to New Castle Harbor, 10 miles above, itself crowded with vessels.

It is proposed during this summer to make a full and careful survey of this locality, with the view of submitting a special report on this subject previous to the next session of Congress.

Reedy Island Harbor is in the collection-district of Delaware, Wilmington, Del., being the nearest port of entry.

Fort Delaware is the nearest fort, and Reedy Island Light is the nearest light-house.

E 14.

IMPROVEMENT OF BROADKILN RIVER, DELAWARE.

Nothing has been done for the improvement of the river since 1874. Should appropriation be made, a resurvey and examination will be required previous to submitting a project for its application.

The long time that has elapsed since the work was suspended for want of funds makes it desirable to have a resurvey to show if any modification of the original project is desirable before expending more money upon it.

E 15.

CONSTRUCTION OF PIER IN DELAWARE BAY NEAR LEWES, DELAWARE.

CONDENSED HISTORY OF THE WORK.

This work had its inception in an appropriation by Congress in July, 1870, of $225,000 for a "substantial pier of stone or iron," at the locality

designated. The late Lieut. Col. J. D. Kurtz, Corps of Engineers, was charged with its execution, and his projects and estimates therefor, printed in the Annual Report of the Chief of Engineers for 1871, have substantially controlled operations since.

The plan adopted was the combination of wrought-iron screw pile-shafts and cast-iron caps and screws, with a superstructure of yellow-pine timber as promising the greatest strength and durability that could be combined with the least interference with the natural currents of the harbor. The pier was to be 1,701 feet in length, to reach 22 feet at low water, and the estimated cost was $387,000.

The first pile was driven in April, 1872, and the original appropriation was exhausted in 1873. Small additional appropriations, insufficient for completion, were made annually thereafter, except in 1877, as follows: In 1874, $10,000; 1875, $40,000; 1876, $30,000; 1878, $20,000; 1879, $10,500. Total to July 1, 1879, $335,500.

Tests of the weight-supporting capacity of the piles were made in 1877, with entirely satisfactory results, except in the case of the 57th row, 1,197 feet from shore. The piles of this row have been taken up and lengthened from 33 to 55 feet, and will be redriven to the gravel stratum which solidly supports the remainder of the pier-head.

Although the past and anticipated expenditures for the completion of this work do not, owing to the decreased cost of labor and materials, reach the total of the original estimate, nevertheless it can be clearly shown that the policy of protracting the construction of a work of this character by insufficient yearly appropriations has been attended by a very considerable addition to its cost in deterioration of material and plant from time and exposure, in frequent serious loss of time, and in the yearly item of maintenance.

ANNUAL REPORT OF OPERATIONS FOR THE FISCAL YEAR ENDING JUNE 30, 1879.

An appropriation of $20,000 having been made in act of June 18, 1878, operations were resumed early in the following month. Advertisements were issued for new material and a contract awarded August 10, 1878, to the Paterson Iron Company for 211,852 pounds of iron. The only bid received for lumber was an exorbitant one, and authority was obtained to purchase in open market. Informal bids were asked with the result of obtaining the 39,207 feet required from Tatnall & Co., of Wilmington, Del., at $26.50 per 1,000 feet.

Meanwhile advantage was taken of the interval that must elapse before the deliveries, to take up and lengthen the 57th row of piles. This row was tested in 1877, and found to possess less stability than it should owing to the comparative softness of the stratum in which the screws of that particular row rested. The details of test and result are given in Annual Report Chief of Engineers of 1878, pages 432, 433. The removal of the collars and braces from the piles gave much trouble from the corrosion of the screw-threads and buckles. A temporary derrick was rigged to aid in moving the girders, taking off the caps, and lifting the piles. Although the weight of these piles with the attached braces, &c., was not over 5,000 pounds each, their withdrawal offered unexpected difficulties. It was supposed that this could be effected by backing the screw and aiding its action by the lift of the derrick, but upon trial it became evident that only a more rapid motion than it was practicable with existing appliances to secure, would render the screw an efficient auxiliary in the soft bottom, while at the same time the weight

of material incumbent upon its upper surface forbade its being lifted bodily. Under these circumstances, recourse was had to the water jet which had been previously successfully applied to reducing the power required to screw the piles down into hard bottom. The pipe having been thrust down alongside the pile and the hand pump set in operation, the application of the jet to the upper surface of the screw enabled the derrick to hoist out the pile with ease, no unscrewing being necessary. The appearance of the piles after an exposure of 5 years to the action of the salt mud and water was as follows:

From the line of the bottom up to low-water mark, they were covered with a closely adhering coat of mussels 6 inches in thickness. These and the mud still clinging to the screw were quite black, the latter changing to gray upon drying. No effect of the contact with the pierced strata could be observed, except that the thin edges of the cast-iron screw had assumed a slight black lead-like softness, and that the wrought-iron band around the hub of the screw was somewhat streaky in appearance, a thin film of the softer fibers having been attacked. The outer scale of the pile itself was still smooth, hard, and bright, with only a few rusty spots here and there. From the level of the bottom up to low water the surface of the pile after the mussels had been scraped off was found to be full of small cavities, and of a streaky, fibrous appearance. The necks about which the collars were clamped were also streaked, but exhibited no cavities; indicating that possibly some chemical action of the attached shell-fish had produced them.

Between low and high water marks the pile was still smooth, but above high-water to the cap considerable corrosion had taken place, imparting a scaly, blister-like appearance. These scales were easily removed.

The process of oxidation expands the film affected, so that the scales were in some cases swelled from about $\frac{1}{62}$ inch to nearly $\frac{1}{8}$ inch in thickness, and the diameter of the pile was sensibly increased even to the eye.

The braces near to and above high-water were also much corroded. The screw-threads are cut perpendicularly to the fiber of the iron, and examination showed that they had been nearly destroyed, making it necessary to cut them off and weld on new lengths for the thread.

A temporary bridge was laid across the break in the pier, and the remainder of August was occupied in removing the superstructure down to the 4×9 joists that rest upon the main girders. This was necessary in view of the fact that it was contemplated to make considerable modifications in this part of the work, and to apply a system of horizontal diagonal braces, for which provision had been originally made in designing the caps. The application of this system of braces will, in effect, convert the entire pier-head into a horizontal truss, and admit of bolting the fenders directly to the pier instead of constructing a fender system independently, as was originally contemplated. The alteration avoids certain practical difficulties pertaining to the independent system, simplifies the construction, and saves expense.

Owing to the lateness of the appropriation, and the delays incident to labor troubles, the new iron material did not arrive until November 2, and the favorable part of the season had elapsed.

The cargo delivered consisted of 10 piles, with their complement of braces, caps, screws, and bolts, of the 5 piles of the 57th row which had been lengthened, and of 52 sets of horizontal braces, with their appurtenances, the whole weighing 122 tons. About the same time the lumber for the pier was received, its delivery having also been delayed by the outbreak of yellow fever at the South.

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The first new pile was driven November 15, 2 more on the 16th, and the remaining 2 of the 80th row on the 19th. Unfavorable sea and weather delayed the bracing until the 26th.

A pile of the 81st and final row of the pier was driven on the 29th November, 3 more the next day, and the final one, number 297, not until December 4. It was a matter of serious congratulation that the derrick had endured to the end, although it was evident that the limit of its usefulness for heavy work had been reached from the frequent breaks and weaknesses developed almost daily. It was for this reason that the pile-work was pushed to completion notwithstanding the disadvantages attending the season, since it was certain that after another winter's exposure new appliances would be required.

It is worthy of mention, and creditable alike to the designers and operators of the special appliances necessary, that during the driving of these 297 piles, whose aggregate weight was over one and one-half million pounds and of which 120 weighed over 5 tons each, no serious injury had been received by any one.

The bracing of the last row was completed finally on December 26, and further operations were at once suspended, with the exception of those necessary to the care of the property during the winter.

The superstructure was not advanced during the year for reasons already given.

The appropriation of $10,500, made in act of March 3, 1879, not having become available by the close of the fiscal year, work still remains suspended.

The condition of the pier July 1, 1879, was as follows: The original number of piles have been driven and completely braced, with the exception of the horizontal system of braces, which will connect the caps of the pier-head diagonally. The substructure therefore extends to its designed length, 1,701 feet, and might be reported as finished but for the break caused by the removal of the 57th row.

In the superstructure 4 girders are laid to 1,533 feet, 4 to 1,554 feet, and the floor joists to 1,530 feet. The decking of the pier-head has been in great part removed.

It is proposed during the ensuing season to complete the substructure by redriving and rebracing the 5 piles of the 57th row and applying the horizontal braces to the pier-head; to construct a landing slip on either side of the pier for the use of vessels, and put enough fender piles in position to admit of their being used; to replace and complete the decking of the pier so far as the material on hand can be applied to this purpose.

During the year ending July 1, 1881, it is proposed, should the appropriation asked for be made, to complete the pier ready for service, lay track from the outer end to the limit of the United States reservation, place mooring buoys in position, and surrender it to its intended uses as a shipping and landing pier under such regulations as the Secretary of War shall prescribe.

Since the derrick will not again be used for driving piles, it will probably be of interest to include in this report a brief description of the methods and apparatus employed during the seasons of 1877 and 1878 to drive the "heavy" piles, 8½ inches in diameter, 55 feet long, and weighing 5 tons, as illustrated in the accompanying excellent drawing by Assistant A. Stierle.

The piles with screws attached were rolled from a shore-staging upon the deck of a scow and hauled to the end of the pier. As soon as the scow had been made fast to the mooring anchors, the "guide" (G), a

strongly-trussed parallelogram with two hinged-clips at either end, was clamped to that pile of the last row set which was in line with the one to be driven and braced diagonally.

For hoisting the piles two purchases are used. The first leads from the upper drum of the engine aloft to the boom of the derrick and terminates in two main hoisting chains, that run over pulleys (P) whose common shaft is attached to a traversing carriage on the boom. The chains depend and are hooked into the levers of the eccentric clamp or nippers (N) applied to the pile near its upper end. The second purchase (called the heel tackle) leads from the lower drum of the engine through a block on the shaft of the main chain pulleys, and terminates in a wire rope which is hooked into a heavy rope strap on the pile near the screw. This tackle having been set taut, the main hoisting gear is put in action with the effect of raising the pile free of the scow, which is at once hauled away. The lifting being continued, the pile rapidly alters its position from the horizontal to the vertical, the heel tackle acting as a fulcrum, movable within certain limits and gradually slackening as the pile rises. The hoisting was frequently done in 1 minute. The heel tackle was then disengaged and the pile swung into the clips of the guide by means of side tackles (W) to the boom, one of which is shown. It was then adjusted, sighted into line with a transit on shore, plumbed, and allowed to descend until it rested in the bottom.

In order to adjust the carriage to its required and variable position on the boom the large fall (F) was used, worked by gearing attached to the mast of the derrick.

The pile usually sank about 10 feet into the soft upper strata, revolving as the weight came upon the lower surfaces of the screw. The chains and nippers having been detached, the capstan wheel (C) was hoisted and lowered over the pile, until carried by short suspension-straps crossing each other on the head on the pile. This wheel consists of radial arms of wood, framed together and let into a central cast-iron collar (X) provided with 3 eccentric cams, whose function was to jam against the pile as the wheel was turned in the gaining direction "with the sun."

The screwing down was done by means of the endless rope or runner (R) wound on the wheel and leading to the lower drum of the engine.

When the pile had nearly reached its proper level, a leveling-rod was held upon it, and observed until the exact depth had been reached. The average time consumed in the whole operation of handling each pile was 2 hours, the most rapid work being 1 hour and 15 minutes, and an entire bay driven in less than 9 hours' working time.

Assistant Stierle, who has been associated with the work since its commencement, and whose intelligence and steady devotion to his duties have contributed in large measure to its uniform success and progress, was in immediate supervision of the year's operations.

This work is in the collection-district of Delaware, of which Wilmington is the port of entry.

Amount of revenue collected during the fiscal year ending June 30, 1879, was $21,821.71.

Delaware Breakwater light is the nearest light-house, and Fort Delaware is the nearest fort.

COMMERCIAL STATISTICS.

Amount of freight forwarded and received at the Railroad Pier, Delaware Breakwater Harbor, from May 1, 1878, to June 1, 1879.

	Pounds.	Pounds.
Forwarded per steamboat	26,136,214	
Forwarded per schooners	6,781,814	
		32,918,028
Received per steamboat	3,240,893	
Received per schooners	18,130,590	
		21,371,483
Total forwarded and received		54,289,511

or 24,237 long tons.

Money statement.

July 1, 1878, amount available	$20,001 09	
Amount appropriated by act approved March 3, 1879	10,500 00	
		$30,501 09
July 1, 1879, amount expended during fiscal year	19,926 47	
July 1, 1879, outstanding liabilities	60 00	
		19,986 47
July 1, 1879, amount available		10,514 62
Amount (estimated) required for completion of existing project		24,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1881		24,500 00

Abstract of bids received by Col. J. N. Macomb, Corps of Engineers, at Philadelphia, Pa., 12 m., July 27, 1878, for furnishing and delivering material for the construction of iron pier near Lewes, Del.

	Names of bidders.	Residence.	First class of material.																			
			Hammered iron.						Rolled iron.													
			Upper cross braces, 16, 14′ 4½″ x 2½″, diameter, 3,500 lbs.		Lower braces, 16, 20′ 7″ x 2½″ diameter, 6,400 lbs.		Pile shafts, 10, 57′ x 8½″ diameter, 102,000 lbs.		Pile shafts, 5, 22′ 6″ x 6½″ diameter, 11,700 lbs.		Screw bucklers, 62, 2,500 lbs.		Longitudinal braces, 20, 26′ 10½″ x 3″ diameter, 13,200 lbs.		Horizontal braces, 32, 21′ 8½″ x 1⅞″ diameter, 9,152 lbs.		Bands for screws, 10, 164 lbs.		Pile shafts, 10, 57′ x 8½″ diameter, 102,000 lbs.		Pile shafts, 5, 22′ 6″ x 6½″ diameter, 11,700 lbs.		Screw bucklers, 62, 2,500 lbs.	
			Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.
			Cents.		*Cents.*		*Cents.*		*Cents.*		*Cents.*		*Cents.*		*Cents.*		*Cents.*		*Cents.*		*Cents.*	
1	Paterson Iron Company	Paterson, N. J	4	$140 00	4	$256 00	4	$4,080 00	4	$468 00	15	$375 00	4	$528 00	4	$366 08	8	$13 12	4	$4,080 00	4	$468 00	15	$375 00
2	River Iron Company	Camden, N. J	5		5		4		4		10		5		5	466 75	8	18 04	4		4		10	
3	Reading Iron Works	Philadelphia, Pa	12½	421 06	7.67	490 88	4.44	4,528 80	5.24	624 78	33.27	831 75	6.15	811 80	5.1	420 99	11	16 40	4.44	4,528 80	5.24	624 78	33.27	831 75
4	Paulding, Kemble & Co	Cold Springs, N. Y	4.6	161 00	4.6	294 40	3.9	3,978 00	4	468 00	20	500 00	4.6	607 20	4.6	366 08	10	6 56	3.9	3,978 00	4	468 00	20	500 00
5	Ramsay & Latrobe	Baltimore, Md	4	140 00	4	256 00	7	8,160 00	5	819 00	5	125 00	4	528 00	4	347 76	4	16 40	7	8,160 00	5	819 00	5	125 00
6	John De Barry	Philadelphia, Pa					4.25	4,335 00	4	468 00	20	500 00	3.8	501 60	3.8		10	16 40	4.25	4,335 00	4	468 00	20	500 00
7	Macpherson, Willard & Co.	Bordentown, N. J	3.8	133 00	3.8	243 20																		

Abstract of bids received by Col. J. N. Macomb, Corps of Engineers, at Philadelphia, Pa., 12 m., July 27, 1878, for furnishing and delivering material for the construction of iron pier near Lewes, Del.—Continued.

	Names of bidders.	First class of material.												Second class of material.				Total amount of bid.
		Residence.	Hammered iron.				Cast iron.							Yellow pine, sawed timber.				
			Bolts and nuts, 114, 3,000 lbs.		Collars and clamps, 20, 5,800 lbs.		Screws, 10, 4,100 lbs.		Caps, 10, 6,700 lbs.		Brackets, 4, 800 lbs.		Stringers, 14, 12″ x 12″ x 42′ = 7,056′ b. m.		Curb pieces, 4, 12″ x 12″ x 42′ = 2,064′ b. m.		Curb pieces, 28, 10″ x 15″ x 44′ 6″ = 15,575′ b. m.		Cross beams, 75, 6″ x 9″ x 43′ = 14,512′ b. m.	
			Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	
			Cents.		*Cents.*		*Cents.*		*Cents.*		*Cents.*		*Cts.*		*Cts.*		*Cts.*		*Cts.*		
1	Paterson Iron Company	Paterson, N. J	8	$240 00	9	$522 00	3¾	$143 50	3½	$234 50		$28 00	4.5	$317 52	4.5	$92 88	4.5	$700 87	4.5	$653 04	$7, 394 20
2	River Iron Company	Camden, N. J	8	.....	10	.....	4	.....	4	.....		.....		.....		.....		.....		.....	7, 707 72
3	Reading Iron Works	Philadelphia, Pa	6.18	185 40	10.37	601 46	4.09	167 69	5.23	350 41	3.44	27 52		.....		.....		.....		.....	9, 526 28
4	Paulding, Kemble & Co	Cold Springs, N. Y.	9	270 00	11	638 00	3.9	159 90	3.9	261 30	3.9	31 20		.....		.....		.....		.....	7, 806 39
5	Ramsay & Latrobe	Baltimore, Md	5	150 00	5	290 00	4	164 00	4	268 00	4	32 00		.....		.....		.....		.....	11, 304 64
6	John De Barry	Philadelphia, Pa	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.5	$317 52	4.5	$92 88	4.5	$700 87	4.5	$653 04	1, 764 31
7	Macpherson, Willard & Co	Bordentown, N. J	4.8	144 00	11	638 00	4½	179 37	4½	293 12	5.8	46 40	...	.....	.....	.....	.....	.....	.....	.....	7, 845 85

REMARKS.—The Paterson Iron Company being the lowest bidders for first class of material, the contract was awarded to them. The bid for second class of material was considered exorbitant and was rejected. Subsequently authority was received to purchase in open market. The price paid in open market was $26.50 per 1,000 feet.

E 16.

DELAWARE BREAKWATER HARBOR.

This great harbor of refuge was first appropriated for in 1828, and its construction begun the following year upon plans submitted by a Board of Commissioners appointed by Congress.

The project of the Board contemplated the construction in the concavity of the bay, just inside Cape Henlopen, of two massive works on the *pierres perdues* or riprap system, separated by an interval or gap of about one-quarter of a mile; the greater, called the breakwater, to afford safe anchorage during gales from the north and east; the other, called the ice-breaker, to protect shipping against northwesterly gales and the heavy drifting ice of the bay.

The stone used varied from one-quarter of a ton to seven tons in weight; the smaller constituting the bulk of the mass, the larger used to cover the exterior slopes and sustain the direct impact of the sea.

By 1839, 835,000 tons of stone had been deposited, at a cost of $1,880,000. Appropriations were thereafter irregularly made, viz, in 1852, 1864, 1866, and 1867, resulting in a total expenditure of $2,123,000.

The work remains substantially as left in 1869. The breakwater is 2,558 feet long on top, the ice-breaker 1,359. The average width of both is 22 feet on top and 160 feet at the base. The top is about 14 feet above mean low-water.

As might be anticipated from the method of construction, there are still indications of movement among the materials composing the mass. The wall of the light-house standing near the west end of the breakwater exhibited fissures, threatening a catastrophe, which was avoided last summer by the extension of the foundations by the Light-House Establishment. Depressions from the upper horizontal line are observable at other points, indicating subsidence. The Breakwater Harbor has now for many years fulfilled, so far as its capacity has enabled it to do so, the design of its projectors in protecting the commerce of the country; but the growth of this commerce, particularly during the last twenty-five years, has so far exceeded possible anticipation as to practically exclude more than a fractional part from the intended shelter. During stormy weather more than one-half the coasters seeking refuge and all the large foreign vessels are compelled to anchor in the roads and up the bay. At various times, therefore, projects looking to the enlargement of the protected area have been the subject of deliberation by officers and Boards of Engineers; and the matter received renewed attention during the fiscal year just closed from the reference by the Chief of Engineers to a Board of Engineers of a report by Capt. William Ludlow, Corps of Engineers, showing, by a comparison of a recent survey with former ones, that not only was the protected area yearly diminishing relatively to the amount of shipping seeking shelter, as had been repeatedly urged in the reports of General Barnard, Colonel Kurtz, and others, but it was also undergoing a positive and serious deterioration from a marked decrease in depth.

Observations of the currents of the harbor, being needed to aid the Board in its deliberations, were made and presented. The report referred to and that of the Board, with the letter of the Chief of Engineers forwarding them, printed as House Ex. Doc. No. 92, third session, Forty-fifth Congress, are forwarded herewith.