filled slope walls with an earth core, the rock fill protecting the earth from erosion by the waves and ice.

There are two abutments and five piers, each founded on piles, and built of concrete from the bottom to a point seven feet below mean tide. From this point to high tide level they are composed of cut granite masonry backed with concrete, and above high tide level of freestone backed with concrete.

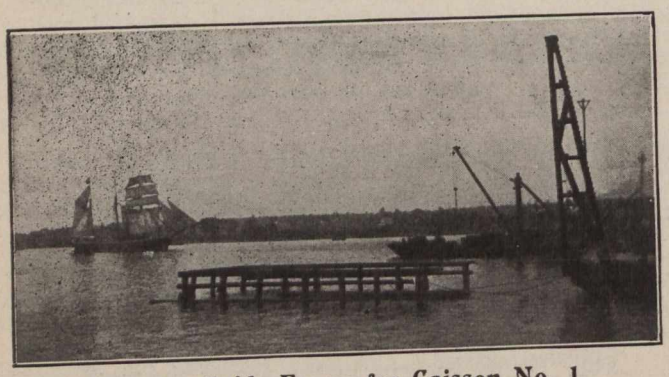

Fig. 4.—Guide Frame for Caisson No. 1.

The abutments presented no unusual features. They were both built in open cofferdams, which were made by driving wooden sheet piling around a built-up framework of 12-in. by 12-in. yellow pine timbers, which formed the braces and wales of the cofferdam. As soon as the sheet piling was completed the cofferdams were pumped out and excavation made to ledge at a depth of twenty-eight feet at the Nelson abutment, and to a hard clay and sand strata at a depth of sixteen feet in the Newcastle abutment. The piles for the latter abutment were then driven with a drop hammer; using an extension lead pile driver; and the concrete of both abutments was placed in dry space.

The five piers presented the most interesting and difficult work. They vary from 56 feet to 69 feet in height and are being built in water from 35 to 48 feet deep.

The plan of construction adopted for these piers was the "Open Caisson Dredging Method." Caissons were framed up of yellow pine timber, twenty-six feet wide (except the pivot pier caisson) and of the height required for each pier. The two largest caissons were 63 feet 6 inches high. The pivot pier caisson was octagonal in shape, 42 feet across and 59 feet 6 inches high. The pivot pier caisson ready for launching is shown in Fig. 1.

All of the caissons were framed up on shore to a height of twelve feet around the first set of binder posts, which in the largest caissons were 31 feet high. The outside walls of this portion were built solid of 12-in. by 12-in. timbers and braced by one longitudinal and four lateral sets of timbers framed into the sides and bolted solidly at the intersections and to the binder posts. The bracing timber was placed in vertical rows so that the caissons were divided into ten pockets, four of which served later for dredging and six of them for loading with sand for sinking. The lower courses and part of the posts of one of the rectangular caissons is shown in Fig. 2.

The launchingways, illustrated in Fig. 3, were built of heavy timbers 30 feet long, laid horizontally and resting at their centre on a 12-in. by 12-in. rocker timber 54 feet long.

The caissons were built on these timbers in a level position and, when ready for launching, the caisson and supporting timbers were tilted on the rocker timber. This brought them in line with another set of timbers leading on the same slope into the water, and the caissons were launched by sliding on these timbers. No cradle or falsework was used and no difficulty was experienced with this method of launching. (Two hours were sufficient to tip and launch the caissons and thirty minutes after launching a caisson the launchingways were ready to start construction of the succeeding caisson).

Pontoons were secured in four of the pockets of each caisson before launching to float it in a level position when launched and hold it at an elevation in the water convenient for working. All of the caissons were lauched sideways as the water was only about six feet deep at high tide where the launchingways were constructed.

After launching, the caissons were tied up at a dock where building up continued until the caissons drew 23 feet of water, the total depth available, and then towed to their final site. They were then built up in place to their finished height, the caissons in every case drawing enough water to rest on bottom before being completed.

The strong current in both directions required special means of holding the caissons in place, the pressure against them being over 50,000 lbs. on the ebb tide at times. A guide frame composed of thirty-two piles, sixteen of which were batter piles, bolted to the other sixteen

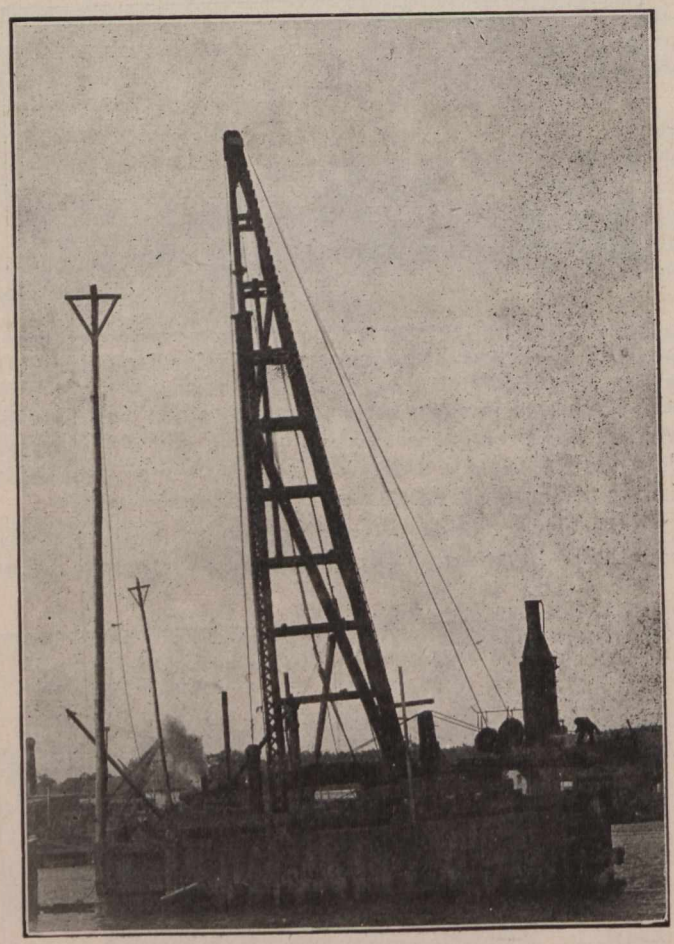

Fig. 5.—Pile Driver.

vertical piles, was driven to from three sides of a rectangle the upstream side being left open, as shown in Fig. 4. These piles were capped and braced in position. Chinese anchors, made by filling timber cribs 16 feet square with 40 tons of rock, were previously constructed and sunk about 400 feet upstream and downstream from the caissons. Each caisson was secured to four of these