London since 1911, but the tendency there of late years has been to drive the piles in groups of two, three, four or more piles, which are enclosed in reinforced concrete cylinders sunk to a level below dock bottom and filled solid with concrete. These cylinders reach to high water level and support the posts and braces carrying the pier deck.

A jetty built recently at Tilbury Docks, London, is 1,000 feet long by 50 feet wide, and is supported on three longitudinal rows of such cylindrical piers. The centre row cylinders are 7 ft. 6 in. in diameter, containing eight piles, while the outer rows are of 5 ft. 6 in. diameter cylinders, with four piles in each.

In Senegal, French West Africa, previous to the war nearly 4,000 lineal feet of reinforced concrete pile wharves were built entirely by the native African labor under the supervision of a few French engineers. The piles used were 13-inch and 16-inch octagonal, spaced 13 feet and 16 feet apart, and carrying a reinforced concrete deck of beam and slab construction. Salt water was used in mixing the concrete for this work, which practice is not one to be recommended in reinforced concrete work.

In a paper read before the Institution of Civil Engineers, and published in Vol. 188 of the Proceedings, S. H. Ellis describes the construction of a reinforced concrete wharf, 1,160 feet long by 174 feet wide, at Lower Pootung, Shanghai. The bottom there consists of mud to a depth of over 400 feet, the top 25 feet of this as a rule forming a fairly solid crust of stiff, sandy clay, which has to be depended on for carrying loads.

The piles used are 14-in. square, driven in groups of four, 15 feet centre to centre of groups. The heads of the piles were cut down to a level between low and high water and there capped with a concrete cap and braced with a system of precast longitudinal and transverse beams. The pier deck, of reinforced concrete beam and

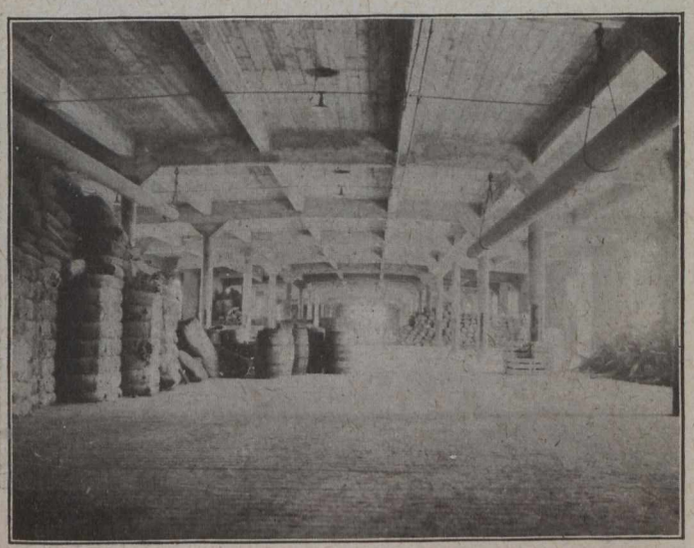

Fig. No. 5—Furness Withy Pier—Interior of Shed

slab construction, is supported on 15-in. square columns, resting on the pile caps. Diagonal bracing is introduced between the pile caps and the deck.

The piles were driven by a single-acting steam hammer, operating a weight of 7,800 lbs., dropping 6 ft. to 8 ft. A final set of 1 in. per blow was usually obtained, which was found by tests to have sufficient resistance to carry the designed load of about 25,000 lbs. per pile without appreciable settlement. Further driving of the piles into the soft mud below decreased their resistance. The water at Lower Pootung is fresh, and after three years no rust stains or cracks were visible on the pile heads or superstructure.

At Los Angeles, reinforced concrete piles have been used to support a timber floor pier. The piles are 20 inches square at their bases, tapering to 14 inches and 17 inches at their tops. They were not driven, but a hole having been jetted into the hard, sandy, clay bottom, the piles were set in the hole base downwards and then consolidated by several blows from a 4,500-lb. hammer. As

Fig. No. 6—Furness Withy Pier—Bent of Cylinders Filled and Braces Set

a contrast to this may be mentioned the practice in New York harbor, where neither the teredo nor the limnoria is to be found, of using timber piles to support a reinforced concrete deck and structural steel shed.

Reinforced concrete sheet piles to form low retaining walls have been extensively used in various ports. One form of pile wall has been described by Sir Francis Spring. The walls were built in Madras Harbor and consisted of 15-in. and 18-in. square reinforced concrete piles, driven by water jet at 8 to 10 feet centres, depending upon conditions, and anchored back by steel ties. Reinforced concrete slabs varying in thickness from 6 ins. to 15 ins. were placed at the back of the piles, the lowest slab having a chisel-shaped edge and being sunk into the sand bottom. The height of these walls varied from 10 to 16 feet above dock bottom.

The use of reinforced concrete cylinder piers was first started at San Francisco about 1906 when two shipping piers each 686 feet long by 130 feet wide were commenced. The cylinders are 3 ft. 6 ins. in diameter, spaced 13 ft. 4 ins. apart transversely, and 15 ft. longitudinally. They were formed by sinking to hard bottom circular wooden forms built strong enough to withstand driving and the water pressure when emptied. All soft mud and water were then removed from inside the forms before they were filled with concrete. Each cylinder is reinforced with eight 1-in. square bars hooped at 9-in. centres with ¾-in. by ⅛-in. bands. The decks are of structural steel I-beams and concrete. Later piers built at San Francisco are of the same type but with all reinforced concrete decks.

At Valparaiso, a coaling pier 655 feet long by 98 feet wide has been lately completed. This pier is supported on 76 reinforced concrete cylinders 13 feet in diameter and varying from 46 to 82 feet in length. In this case the