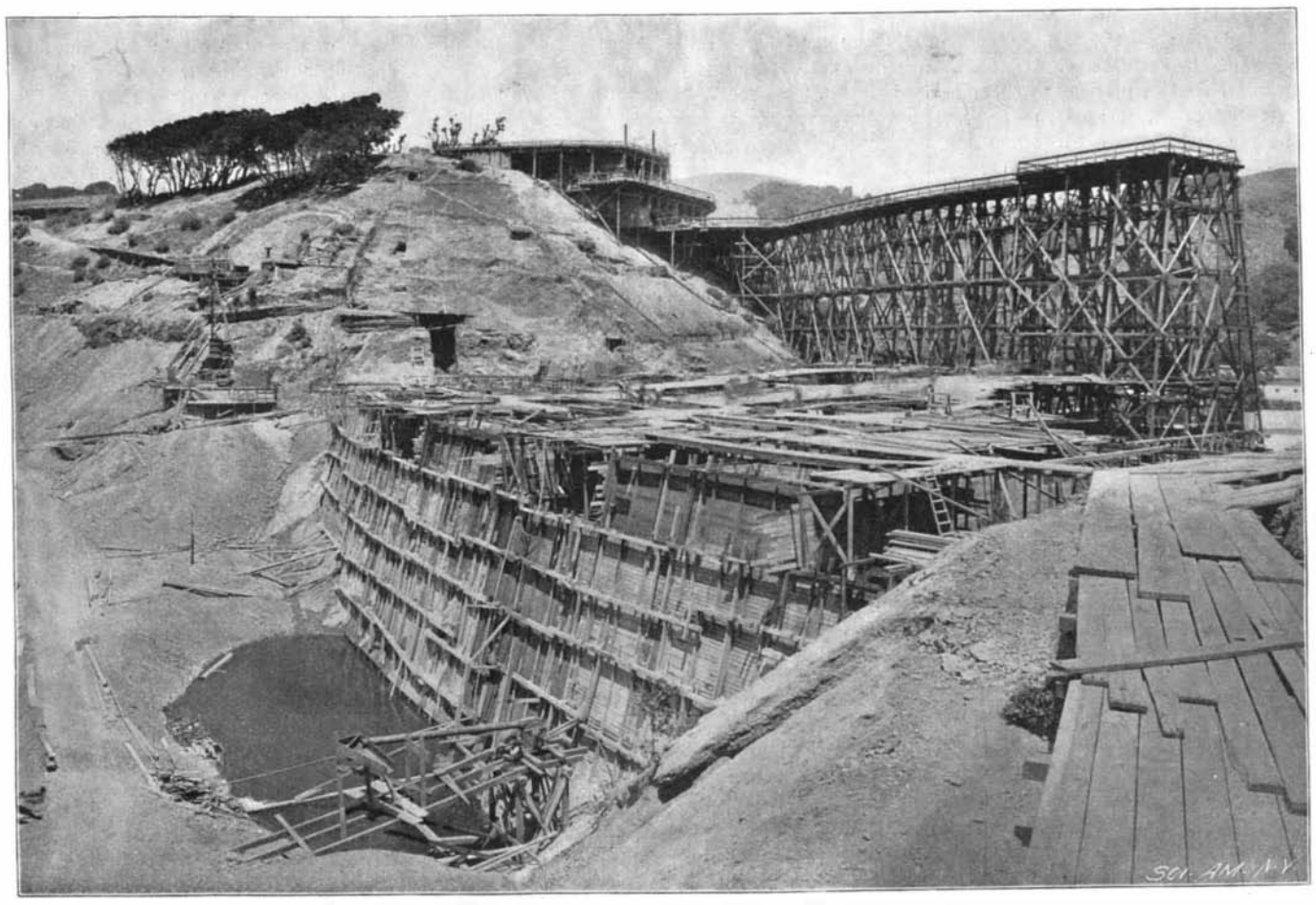
A GREAT CALIFORNIA DAM.

The largest concrete structure in the world, and the highest dam in the United States as well, is located five miles west of San Mateo, Cal., a suburb of San Francisco, from which it is distant about twenty miles.

The Crystal Springs dam is celebrated among engineers for its magnitude as well as for the original methods and principles which are involved in its construction. It was determined to avoid the difficulties met with in dams of even much smaller dimensions, constructed on the monolith plan, from the shrinkage and cracking of the concrete; and the engineer of the company, Mr. Herman Schussler, devised a dam of large dimensions composed of individual blocks, building each block separately, so as to give the blocks an opportunity to set and harden by themselves.



6.—General View of the Sweetwater Dam During Construction.

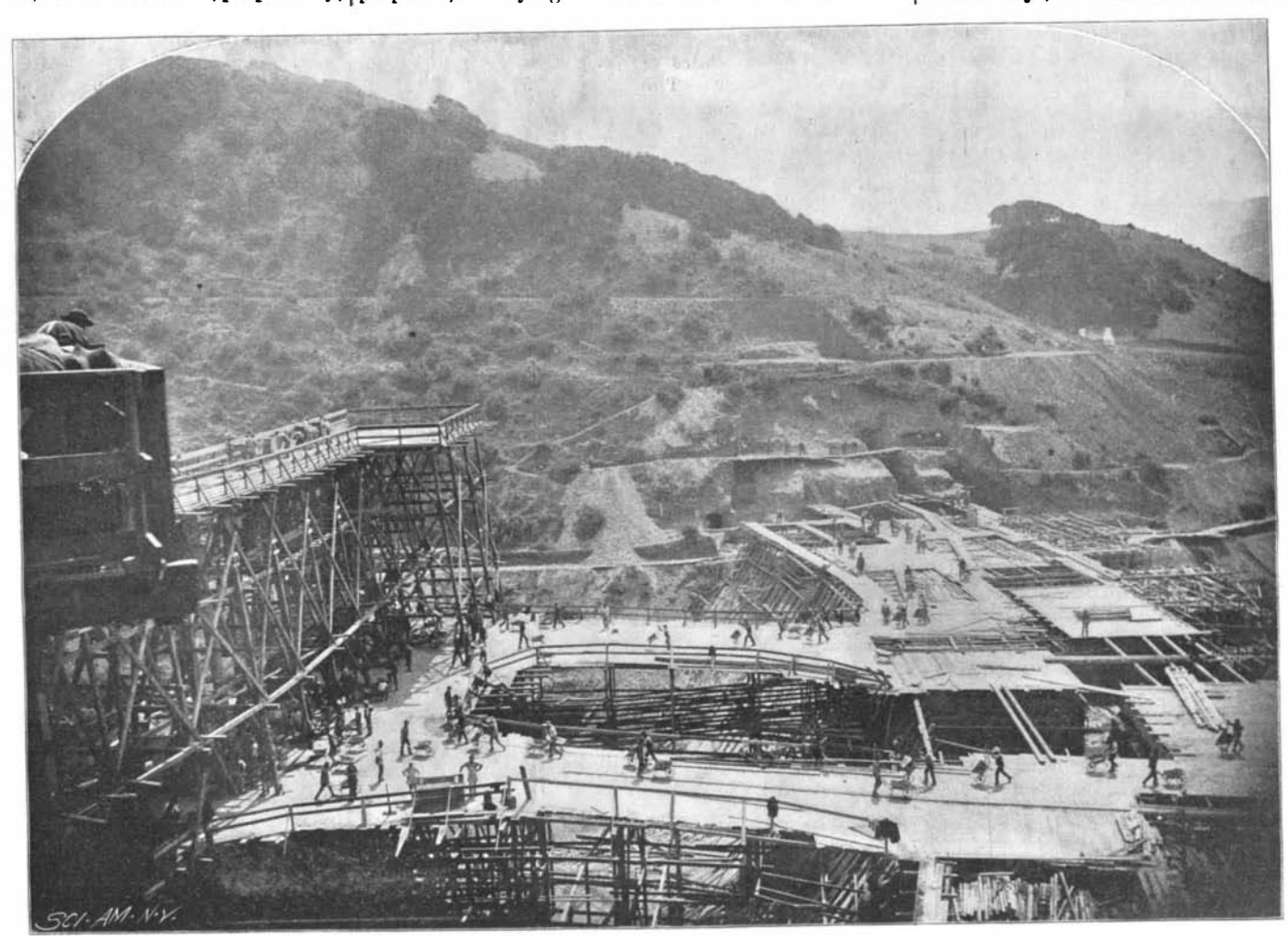
The site for a great artificial reservoir at this point could not have been surpassed. The lower terraces of the range of mountains which start from the Golden Gate and traverse San Mateo County from north to south here approach the lower bay of San Francisco, and at the dam site the rocky walls of the canon, rising to a height of over 200 feet above the bed of the creek, meet within 700 feet, inclosing a valley of large dimensions that spreads out in either direction for long distances, and with the dam at its present height, 145 feet, forms an artificial lake nearly nine miles in length. The task, therefore, of this great structure is to restrain an enormous body of water, and to withstand, perpetually, a pressure of 130,000 tons against its face at its present height.

The present height of the dam is 145 feet. At the base it is 176 feet thick. On the summit it is about 700 feet long and 40 feet thick. The plans contemplate an addition of 30 feet to its present height, making a total of 175 feet in extreme height, with a total length of about 830 feet. The lake thus occasioned will contain 29,000 million gallons of water.

Fortunately, the geological formation of the locality was favorable to securing a reliable foundation. The rock is hard blue sandstone, extremely dense and compact, and entirely free from cracks or fissures. The site for the dam was scientifically exploited, and hundreds of borings, some to a depth of 100 feet, were driven into the rocky sides of the cañon. All required conditions were found at the site selected. Preparatory to laying the foundation the whole bottom and sides of the cañon were cleared of all soil and vegetation until the bed rock was uncovered. The entire foundation was then hewn out to a depth of from 8 to 35 feet. No explosives whatever were employed in this work, in order that the bed rock might not be either broken or cracked. All the softer portions of the rock were cut out, leaving the hard rock undisturbed, thus allowing the superstructure to dovetail itself into the rock base. In order to insure that the foundation should be absolutely watertight, a trench 17 feet deep, 10 feet across at the top, and 5 feet wide at the bottom, following the center line of the dam from end to end, was hewed out of the rock base down to the absolutely watertight ledge below. The excavation will be noticed in the hillside at each end of the dam, in illustrations 6 and 7. This trench was then filled with concrete and heavily rammed.

The bed rock foundation having been thus carefully prepared, the laying of the concrete blocks to form the superstructure began. The bed rock was first cleaned from all debris and dirt and thoroughly hosed. These blocks (see Plate 1) averaged 40 feet in length, 30 feet in width, and 8 feet in thickness, and each was a day's work in itself. Two such blocks were built daily. Separate blocks were built first over the surface of the dam, each having niches and projections on the tops and sides. The first set of blocks may be likened to the black squares set in a chessboard. After the dam had been covered by these blocks and they had set and hardened, the spaces between them, which represent the white squares on the chessboard, were filled in by the second series of blocks. The niches and projections in the blocks of the first tier fitted closely into the secondary blocks (see Fig. 2), breaking joints with them so perfectly that not only were the blocks tied together in a most substantial manner, but watertight broken joints were made between the two series of blocks. The primary tier of the next stratum of blocks was then commenced, these primary blocks being so placed that their centers came approximately over the junction of four of the former blocks. In this manner construction of the dam continued until finished to its present height. In all, 500 of these blocks were used.

For their construction, a framework of varying dimensions and irregular in outline, according to the shape of the block required, was built up at its proper place on the dam. Concrete was gradually dumped into this mould until at last it was filled. As fast as it was thrown in it was carefully spread out and rammed down with heavy iron rammers into a compact mass. The block was allowed to remain in the framework for several days, or until the moisture had evaporated, by which time it had become as hard as the rock upon which it stood. This method was followed with each block. No two blocks were identical in shape or size, each interlocking with its neighbors and contributing combined support to all of the others. The device of building this dam with a large number of separate blocks, instead of as one great mass of concrete, is the distinguishing feature of its construction, and provides the elasticity which secures it from damage in the event of shrinkage.

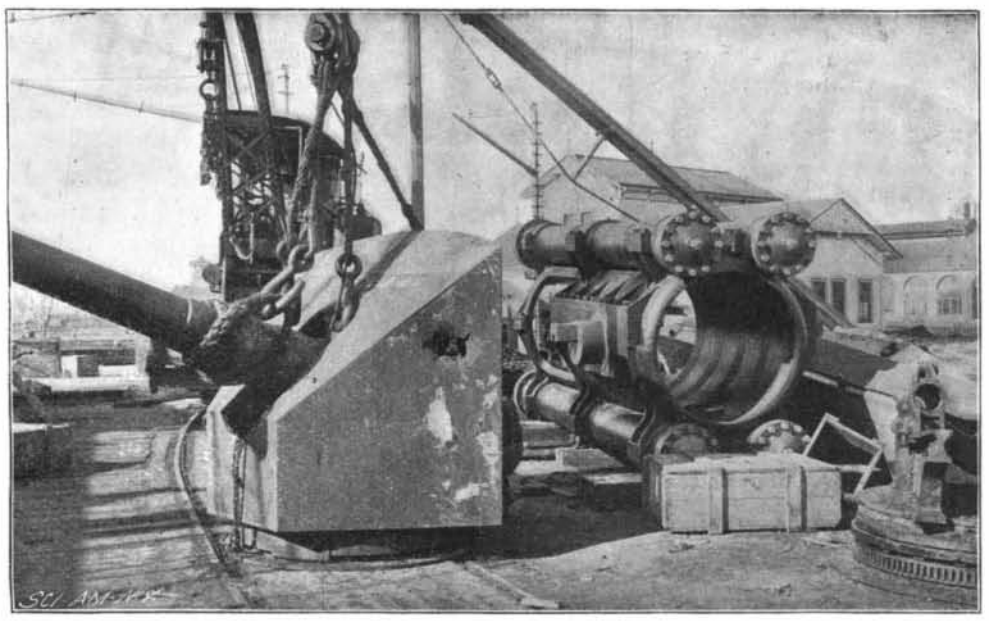


7.—Staging and Platforms Used in Preparing and Mixing the Concrete and Wheeling it to the Dam.

CONSTRUCTION OF THE CRYSTAL SPRINGS DAM, CALIFORNIA.

The sand used in mixing with the concrete was procured at North Beach, San Francisco. Rock of the required density and strength was procured in unlimited quantities, only a mile away from the dam, from a quarry owned by the company. Mechanical devices for making the concrete and transporting it around the dam were employed whenever it was possible.

A great framework consisting of three platforms was



1.—A 5½-INCH GUN FROM THE "OQUENDO."

Shield penetrated by shell at Santiago. Saddle of 13-inch gun for the "Kearsarge" seen to the right.

first erected (see Figs. 6 and 7.) On the first platform the great rock-breaker was placed, which reduced the rock to about the size of a walnut. On the platform below was stored the sand and cement. The broken rock, after being washed, was dumped through a chute into a large iron drum holding six barrels or about twenty-two cubic feet. A car holding two barrels of sand and one barrel of cement was brought forward, and in this proportion the whole was dumped through a chute into a mixer placed on the platform below, water for the concrete being fed in proper quantities through a nozzle in the axle of the mixer.

Power for operations was supplied by three detached engines situated on the lowest platform. After the sand, rock, and cement were thoroughly mixed, the material was dropped into cars running upon a trestle and carried over the dam where the last block was being formed, each car load being dumped through a large pipe to a platform, and thence by wheelbarrow (see Plate 7) into the frame on the dam site where the block was to be stationed. This plan was followed successively until the dam was completed. The capacity of the concrete machines was 450 barrels, or about 10,000 cubic feet, daily. The amount of material consumed gives some indication of the great size of the work. It included 205,000 barrels of the best Portland cement, 410,000 barrels of sand, and 1,230,000 barrels of rock.

The front slope of the dam is 1 foot horizontal to 4 feet vertical; the rear slope commences 1 foot vertical to 1 foot horizontal, ending in the upper 60 feet with a slope 2 feet vertical to 1 foot horizontal, the two rear slopes being connected by a curve of about 300 feet radius. The convex side of the dam, which is upstream, is curved with a radius of 637 feet.

ENOS BROWN.

GUNS RECOVERED FROM THE SPANISH CRUISERS.

There has recently been brought up from Cuba, and unloaded at the Washington navy yard, a considerable amount of material which was recovered by the wrecking companies from the wrecks of Cervera's fleet. It is a miscellaneous collection, of guns, gun shields, projectiles, chains, ship stores, and general fittings.

The most conspicuous part of the salvage is the breech-loading rifles, from the secondary batteries of the Spanish cruisers, and the shields and mounts which accompany them.

Our illustrations are from photographs taken at the Washington navy yard, soon after the material had been unloaded from the United States collier "Leonidas," and it will be seen that the trophies carry upon them the unmistakable mark of the two agents, shell fire and conflagration, which brought about the speedy destruction of the Spanish fleet.

The guns shown in our illustrations have been recovered from one or other of the three sister ships, "Vizcaya," "Maria Teresa," and "Oquendo." These vessels carried as their main armament two 11-inch rifles and ten 5½-inch breech-loading rifles. The 11-inch guns were in two turrets, one forward, one aft, while the 5½-inch guns were arranged in broadside, amidships on the main deck. In the case of the "Vizcaya," the 5½-inch guns were of the rapid-fire type, we believe, but in the other two ships they were of the old slow-fire pattern.

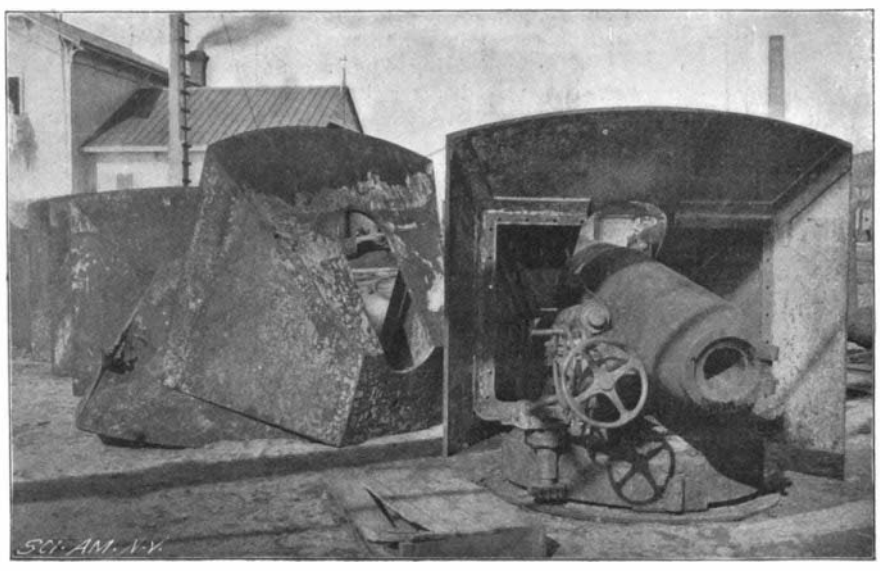
The 5½-inch guns are of what is known as the Hontoria pattern, of the year 1883. They have a total length of about 17 feet, the length of the bore being 35 calibers. The total weight of the gun is 4·1 tons, and it fires an armor-piercing projectile weighing 86 pounds and a common shell weighing 75 pounds. For the armor-piercing projectile the firing charge is 44·1 pounds of powder, which gives the shell a muzzle velocity of 2,001 feet per second, equivalent to a muzzle energy of 2,386 foot-tons. At the muzzle the penetration would be about 14 inches of iron.

The mounting is seen very clearly in the illustration (Fig. 2), showing the breech and inside of the shield of one of these guns of the slow-fire pattern. The gun is trunnioned in a top carriage, which travels during the recoil upon the slides of the lower carriage. The trunnions are formed on the gun, as is usual in all slow-fire weapons, and they can be seen on any of the dismounted guns shown in our various engravings. The lower carriage rotates upon a circular bed of rollers, below which, encircling the foundation plate of the mount, is a circular vertical rack, the rollers and rack being protected from projectiles by a circular casing which is bolted to the carriage and rotates with it. The upper and lower carriage, the turn-table, and the rack, without the casing, of one of these mounts, are shown in the lower right-hand corner of cut No. 1.

The gun is traversed to right or left by means of the hand wheel to the left of the breech, which, by means of a worm, worm-wheel, vertical shaft, and a pinion engaging the circular rack, rotates the carriage about the rack, the latter, of course, being bolted to the stationary foundation plate. The elevation and depression of the gun is accomplished through another hand wheel which acts on a pinion and a circular vertical rack attached to the gun.

Two of the circular racks are shown in Fig. 3, resting upon a dismounted Spanish gun.

All of the guns were provided with shields of comparatively light construction, the thickness, even at the vertical front end, not being over one inch. They are carried on the bottom carriage, to which they are attached by bolting at the front end, and by means of a square frame of angle-iron, which passes round the interior of the shield and extends inwardly to meet the carriage, to which it is bolted. These shields are of sufficient size and thickness to protect the gun crew from machine bullets at close quarters, and from one and six-pounders at long range; but, for protection against anything above a machine gun at close range, or above a six-pounder at any fighting range, these light shields are worse than useless. They cannot keep out the shells, and they merely serve to afford sufficient shock to burst a shell, which, but for the shield, might pass harmlessly by without striking any of the gun crew. In any case, it is not likely that more than one member of the detachment would be struck, whereas a shell that burst in passing through the shield, might kill every man at the gun.

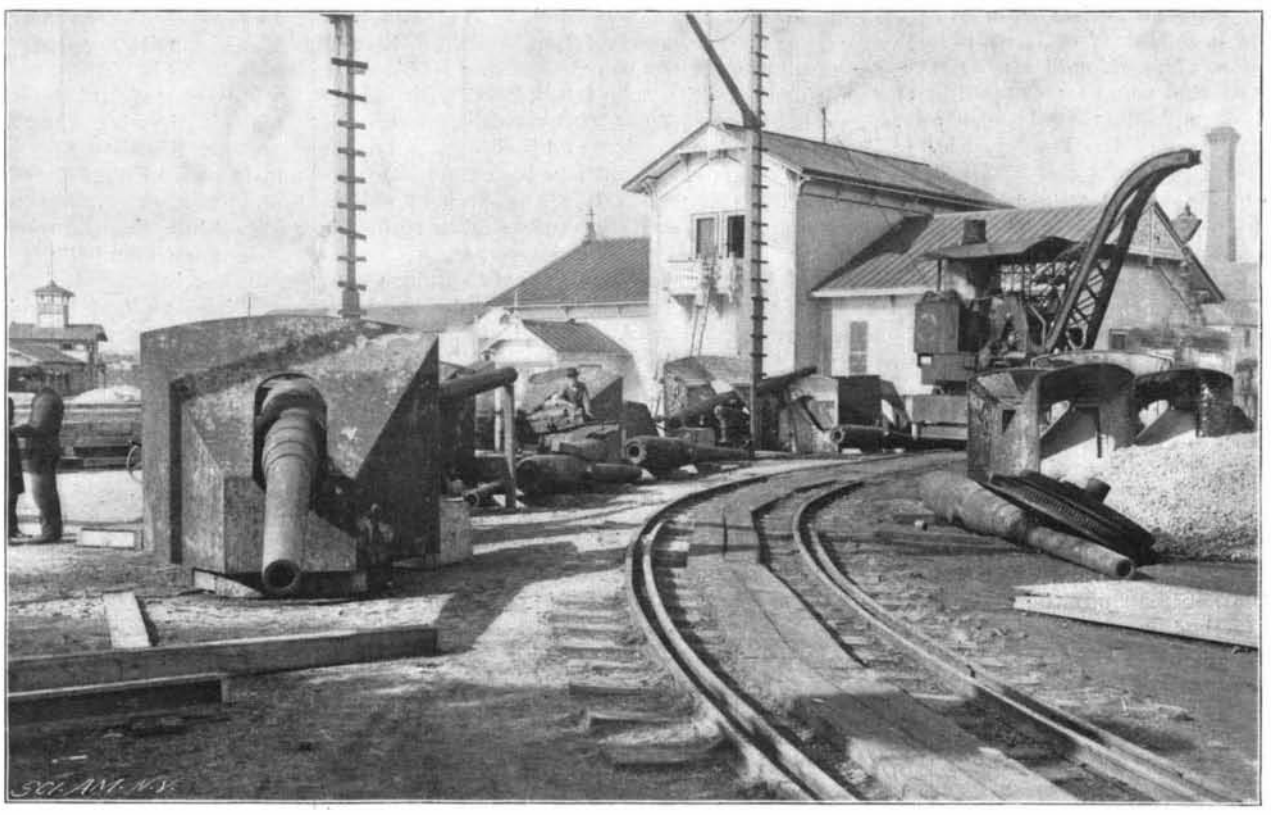


2.—VIEW SHOWING BREECH AND MOUNTING OF A 5½-INCH GUN.

The third shield (from the "Vizcaya") shows effect of shell passing through from the inside.

All the guns bear evidence of the attempt of the Spaniards to render the guns valueless before they fell into the enemy's hands. It will be noticed that the breech-blocks are all missing. They were unhinged and thrown into the sea before the surrender. If our government wished to use the guns, however, it would be easy to replace the blocks, as the Navy Department has drawings of them on file.

It is not likely that any of these guns will be put to active use, for it would entail the introduction of another size of ammunition into the navy, where there is a natural desire to keep down the number of different patterns of guns to the lowest practicable limit. It is not unlikely that the guns will be mounted as trophies at the Naval Academy, and in various public places throughout the country.



3.—SPANISH GUNS, WITH THEIR MOUNTS AND SHIELDS, AT THE WASHINGTON NAVY YARD, TAKEN FROM THE SPANISH WRECKS AT SANTIAGO.

A BROKEN-WINDED horse is rarely seen in Norway. A bucket of water is always placed within his reach when feeding, and the animal alternately takes a mouthful of hay and a sip of water.