

tion the fact that the waters of the river Ottawa, last spring, rose twenty feet above the summer mark; and some conception can then be formed of the strength of the dam required to resist a body of water of so great a magnitude and over 2000 feet wide, rushing over its top, bearing with it fields of ice, trees and other debris. The dam that shall shoulder back and resist, for years to come, the ever-rushing waters of this the greatest tributary of the St. Lawrence must be a work of the first magnitude; for so powerful a river is the Ottawa that, when its waters reach the St. Lawrence, they force back those of its mightier rival for some distance, and the dividing line between them can be distinctly traced for many miles, as they struggle on side by side, until forced to mingle in the boiling waves of the Lachine rapids, at the foot of which they issue forth in one united body.

### REMOVAL OF THE HELL GATE ROCKS.

(See page 356.)

The great obstruction impeding the ship travel between the Atlantic ocean and New York city *via* Long Island Sound is located at a promontory of Long Island, called Hallett's Point; it extends out into the East river, approaching Ward's Island, which occupies three fifths of the width of the river at that point, and some dangerous rocks are found in the immediate vicinity. The narrow channel thus formed has been a danger and a difficulty to navigators ever since this part of the country was first explored, and the rush of water taking place through the pass gave it the name of Whirl Gate, afterwards Hurl Gate, whence the name by which it is now known was easily derived.

Our readers have been informed, from time to time, of the progress of the great work of excavation, which has now been completed; and the blast which will shortly take place will put an end to this difficulty in navigating this now dangerous pass, and end the years of labour that have been so perseveringly bestowed upon it. A very widespread interest has been centred on the operations; and the work is one of national importance, although this city is of course more interested in it than any other section of the country.

The first mention of preparations for commencing this work is found in the report by Lieutenants Davis and Porter, of the United States navy, made in the year 1848. This document gives a very accurate description of the course of the tidal currents, the dangers to navigation caused by rocks, obstructions, etc.; and it recommends that Pot Rock, the Frying Pan and Way's Reef be blasted and scattered. The two former are single rocks of a pointed shape; the latter is long and has the character of a ledge. The report also recommends that the middle channel be improved by blasting so as to make a clear channel of sufficient depth for common vessels and steamboats; and it also speaks of the increased facilities for naval defense which this improvement would afford. The difficulty of blockading the port of New York, with her two outlets instead of one, would be at least doubled. Lieutenant Porter did not exactly agree with Lieutenant Davis as to the best plan for improving the channel. They both recommended the removal of the small rocks—Frying Pan and Pot Rock—from the middle of the channel, and Porter included a part of the reef at Hallett's Point. But the art of blasting under water was almost unknown at that time, and engineers agree that even the little improvement recommended by them could not have been effected without the inventions and discoveries which have since been made. The process adopted in those times for submarine blasting was to take down cans of powder, place them against the side or top of the rock, and explode them by means of a galvanic battery. This did well enough for rough and jagged rocks and boulders; but so soon as the surface had been leveled off, it was of little or no use to attempt to continue the operation.

In 1852, Congress having made an appropriation of \$20,000 for the removal of rocks at Hell Gate, Major Fraser, of the Engineers, began operations according to the Mailefert process above described. The sum of \$18,000 was expended on Pot Rock, and the depth of water was increased from 18'3 feet to 20'6 feet.

This is all that has been accomplished up to 1868, when the duty of an examination of Hell Gate was committed to General Newton of the United States Engineers, who made his report in

January, 1867. For operating on the rocks in the middle of the channel a steam drilling cupola scow was constructed. It had a well hole in it 32 feet in diameter, through which 21 drills were worked, while the scow lay on the surface of the water directly over the rock to be operated on. This formidable machine was first used in the spring of 1869, on Diamond reef. A large number of holes were drilled into this rock, varying from 7 to 13 feet in depth,  $4\frac{1}{2}$  feet in diameter at the top and  $3\frac{1}{2}$  at the bottom, and the rock was broken up by charges of nitro-glycerine of from 30 to 35 lbs. Coenties Reef was operated on in 1871. Ninety-three holes were drilled and charged with nitro-glycerine, and seventeen surface blasts were made. In 1873, three hundred and seven holes more were drilled and thirty-nine surface blasts were made. The amount of nitro-glycerine consumed was 17,127 lbs., and the reef was thoroughly broken up. The *debris* had been partly removed, when, in 1875, Congress, owing to a mere clerical blunder, failed to include Diamond reef in the appropriation, and work at that place had to be suspended. In 1872 the drilling scow was towed to Frying Pan rock. Seventeen holes were drilled and eleven surface blasts made.

### COMMENCING THE WORK.

Operations for removing the reef at Hallett's Point were begun in August, 1869. A coffer dam was built of heavy timber, securely fastened to the rocks by bolts passing through the framework. This structure is shown in our engraving, Fig. 1.

The coffer dam was pumped out about the middle of October, and operations on the interior for sinking the shaft were begun early in November, and continued till the middle of June, 1870, when work was suspended on account of the funds appropriated for this part of the work being exhausted. At that time 484 cubic yards of rock had been taken out, at a cost of \$5,75 per yard. In the inner part of July, operations were resumed, and during that fiscal year the shaft was sunk to the required depth of 33 feet below mean low water, and the heads of the ten tunnels opened to distances varying from 51 to 126 feet. Two of the cross galleries had also been opened. The amount of rock excavated from this place that year was 8,306 cubic yards, and the drilling was all done by hand. During the next year the use of steam drills partially succeeded hand drilling, and the work was pushed more rapidly. The number of feet of tunnel driven during the year was 1,653, and of traverse galleries 653'75. The quantity of rock removed was 8,293 cubic yards.

A sectional view of one of the cross galleries or avenues is given on engraving Fig. 2; and a ground plan of the work, Fig. 3, gives an excellent idea of the extent of the excavation, which is now complete. A longitudinal section of one tunnel called by General Newton "Grant heading," is given in Fig. 4.

An exceedingly well executed model of the works is now on exhibition in the United States Government Exposition at Philadelphia. It is made exactly to scale, and well represents the nature and extent of the vast operations that have now been successfully completed. The rock bed of the river is, in the model, raised from the pillars that support it, so that a close inspection of the interior may be made. There are 172 of these pillars, pierced with about 4,000 drill holes; and the shell, or roof, or bed of the river varies from 6 to 16 feet in thickness. No less than 30,000 cubic yards of broken stone will be left under water, all of which will have to be removed by dredging. The model referred to is accurately represented in our Fig. 5, and Fig. 6 shows a birdseye view of Hallett's Point, with the large coffer dam inclosing the entrance to the submarine works.

### THE RIVER SURVEY.

A detailed survey of the upper surface of the reef was made in 1871 by Mr. William Preass, assisted by Mr. F. Sylvester. They took more than 16,000 soundings, each separately located, by means of instruments, from the shore. Great pains were taken to delineate exactly the surface of the rocks. The appropriation of 1871 was \$225,000, just one half the amount asked for by General Newton, who regretted that the beginning of operations on the Gridiron was thus prevented, as he considered this rock more dangerous to the navigation of large vessels than the Hallett's Point reef. For the next year he asked \$600,000, but got less than half that sum. About the middle of November, 1873, work was suspended for want of funds, but at the end of the first fiscal year, June 30, 1874, it was found that, for the four months and a half during which operations had been carried on, 896 linear feet of tunnels had been opened, and 4,648 cubic yards of rock removed. The total length of tunnels and galleries then amounted to 6,780'67 feet. The excavation now being nearly finished, the manner of finally blowing up the whole mine began to exercise the minds of the engineers.