

source from which a supply of clean water could be obtained. It was resolved to reach those depths by a tunnel under the bed of the lake, tapping its bottom at a distance of two miles from the shore. Surveys of the lake-bed by means of an auger inclosed in a tube, revealed the favorable circumstance of a continuous underlying stratum of hard blue clay. The contract for the bold undertaking was awarded in October, 1863, to James Gowan and James J. Dall, of Harrisburgh, Pa., at the sum of \$315,139. They have already expended more than double this amount, mainly in consequence of the enhanced prices of labor and materials; and it is expected that, with all changes, improvements and finishing touches, the water-works will not be completed for less than \$1,000,000. The contractors have as yet received no relief; but their splendid success warrants the expectation that the city of Chicago will not suffer them to go either unrepaid or unrewarded.

Work was begun at both extremities—the shore end and the lake end—of the tunnel. At the latter point the great engineering difficulty, and triumph occurred. The violent storms on the lake, it was thought by eminent engineers, would make it impossible to fix a permanent structure in the waters. A huge wooden crib, or coffer dam, was built, like a ship, on the shore, launched, and stowed to its location. It was 40 feet deep, five-sided, 290 feet in circumference, and over 90 feet in diameter. Its angles were armored with iron two and a half inches thick. It had three distinct walls or shells, one within another, each constructed of twelve-inch square timber, caulked water-tight like a ship, and all three braced and girded together in every direction, with irons and timbers, to the utmost possible pitch of mechanical strength. The central area, or well, inclosed by the inner wall, was only twenty-five feet in diameter; leaving spaces about fifteen feet wide between the shells. Within these spaces were constructed fifteen caulked and water-tight compartments, which were filled with clean rubble stone, after the crib was placed in position. By this means the crib was sunk to the bottom, where it was firmly moored by cables reaching in every direction to huge screws forced ten feet into the bed of the lake. The water in which it was sunk was 35 feet deep, leaving five feet of the structure above the surface. This was in June 1865. The crib had cost \$100,000; consuming 618,625 feet of timber, 65 tons of iron, and 400 bales of oakum.

The next business was to sink a water-tight shaft within the well of the crib, and into the bottom of the lake to a depth of some thirty feet further; making 66 feet in all below the surface of the water. Seven great iron cylinders were cast, each about 9 feet long, nine feet in diameter, 2½ inches thick, and weighing 30,000 pounds. One of these cylinders having been suspended in the well, another was placed upon it, the two were firmly bolted together with a water-tight joint, lowered, a third cylinder bolted to the second in the same manner, and so on until the shaft, a solid iron tube 64 feet deep, rested on the bottom, and forced its way by its own weight through the softer deposits into the hard blue clay beneath. The water was now pumped out, the top of the shaft was closed as nearly as possible air tight, and a

powerful air-pump, driven by steam, commenced to exhaust the air also. As fast as a vacuum could be created, the atmospheric pressure, added to its own weight of over one hundred tons, forced the huge shaft downward into the bed of the lake with inconceivable force. Thus a depth was reached and secured, at which it became perfectly safe to carry forward the excavation, and complete the shaft to the level at which the tunnel was to begin. The loose rubble stone is finally to be taken out of the water-tight compartments, one at a time, and they will be re-filled with piers of solid masonry, laid in hydraulic cement, and united above the surface in some manner, so as to present an immovable front on all sides against the force of storms. A light-house is to surmount the whole.

The process of constructing the rest of the tunnel was simple, though interesting. Three sections of great cast-iron tubing, like that used in the lake shaft, were let into the earth by simply excavating beneath them, and letting them sink as the earth was removed. Having thus worked through the sands, and into the blue clay, the shaft was now narrowed to eight feet, and completed and walled in the ordinary manner to a total depth of 77 feet. This shaft was sunk four feet further below the surface of the lake than the lake shaft; causing a descent of two feet to the mile in the tunnel, to facilitate emptying it when required.

Both shafts having been completed, the excavation of the tunnel was commenced from both ends. On the 16th ult., the opposite gangs of workmen were within two feet of each other; and on the following day, the Board of Public Works formally broke through this last natural obstruction to the passage of the pure waters of the mid-lake into the city of Chicago. The accuracy with which the two lines of excavation met was an admirable engineering success. The centre lines coincided within nine and a-half inches, and the floors joined with a difference of only one inch. The tunnel is nearly a true cylinder, of five feet diameter in the clear, but worked two inches higher, vertically, on account of the key stone of the arch. It is lined with the best of brick and cement, 8 inches thick, laid lengthwise, in two shells, like toothing joints. The lining of the shore shaft consists of twelve inches of the same masonry in three shells. About 4,000,000 of bricks were used.

Ground was first broken on the 17th of March, 1864; and the work has been continued with but slight interruption, night and day, and at all seasons. A narrow railway was laid from the foot of each shaft, as the work progressed, with turn-out chambers for the passage of meeting trains; and small cars, drawn by mules, conveyed the excavated earth to the hoisting apparatus, and brought back at every trip a load of brick and cement. The men worked in gangs of five, at the excavation; the foremost running a drift in the centre of the tunnel, about two and half feet wide, the second breaking down the sides of the drift, the third trimming up the work to proper shape and size, and the last two loading the earth into the cars. The bricklayers followed closely, only a few feet behind the miners. About a hundred and twenty-five men employed in this work, in three relays, working eight hours each; the only cessation being from 12 o'clock Saturday night, to 12 o'clock Sun-