

upper air lock. In the middle, between the tunnel openings, is shown the lower curved end of the chute for passing in bricks and other small materials, and which, in emergency, might serve as an additional way out for workmen. Fig. 4 represents the opposite side of the working chamber, with the telephone closet, compressed air pipes, electric lamp, windlass for operating the cable roads to the breast of the tunnel, etc. The tram cars laden with clay from the forward workings, are hauled to the shore end of the tunnel, where they are automatically dumped (as shown in Fig. 3) into the puddle underneath the floor of the working chamber. Here the clay is worked up with water to the consistency of cream and forced, by the air pressure in the tunnel (from 19 to 21 pounds according to the state of the tide) up through the blow-out pipe to the surface, where it is used for filling in low ground.

From the working chamber the visitor may enter either of the tunnels and follow the tramway to the breast, now between 450 and 500 feet distant, and advancing from $3\frac{1}{2}$ to 4 feet a day. As he approaches the working end of the tunnel the roadway suddenly dips downward and the tunnel becomes a full cylinder. The guide explains the purpose of keeping the tunnel half full of clay to be two-fold—to partly relieve the strain upon the brickwork while the cement is hardening, and to furnish a broader passageway for men and materials. By this plan the full diameter of the tunnel is available for roadway.

The method of advancing the work can be described in few words when so much has been shown by the artist. The material to be removed is an extremely compact blue clay, which thus far has proved to be encouragingly free from softer streaks, seams, or other breaks, by which water can enter or compressed air escape in serious quantity. The advance is made cautiously, though, as already noted, with considerable rapidity.

First the quality and consistency of the material ahead are approximately determined by driving in slender rods of iron from the forward end of the pilot tunnel, which is $6\frac{1}{2}$ feet in diameter. The breast of the pilot tunnel is kept from 15 to 20 feet in advance of the forward working of the tunnel proper. In this way any possible change in the character of the ground must be discovered before it can be a source of imminent peril to the main work. Besides, the pilot tunnel furnishes a substantial support for the braces which hold in place the advancing iron plates of the main tunnel until the successive rings are completed and the brickwork built up. The pilot tunnel is composed of ten segments or rings of stout iron plates, each 4 feet long, the whole securely bolted together and braced within by beams of wood (not shown in the engraving), to counteract the thrust of the exterior braces. This pilot tunnel is continually built up at the forward end as the clay is removed, the plates for the advancing segments being taken from the rear end, which has been passed by the advancing brickwork.

The main excavation follows the pilot in six or eight terraces or steps, and the iron shell of the tunnel is advanced section by section as the clay is removed, the construction of the rings going on from the top around the sides until each ring is completed. When four rings (or ten feet of the shell) have been completed and securely joined, the circle is bricked up and finished with a coating of Portland cement.

The visitor cannot but be favorably impressed by the excellent character of the work now being done, and by the increased care taken to reduce to the smallest the inevitable hazards of a work of this nature. Two new features in the prosecution of the work will command especial approbation. These are the introduction of solid bulkheads with double air locks near the working ends of the tunnels, and the construction of an air-light diaphragm filling the upper half of each tunnel, at a point still closer to the men engaged in excavating, plate laying, and brick laying. By means of these precautions the danger to the workmen from any possible inrush of water will be materially reduced. Work upon the bulkhead for the south tunnel is now going on, and at the time of our visit (May 17) the air locks were being put together for testing. The bulkhead will be placed at a point near where Fig. 2 begins; and the intention is to have one of the air locks always open as a refuge for the workmen. The diaphragm will be placed near the rear end of the pilot tunnel. Its office will be to prevent the outflow of air from the upper half of the tunnel between the diaphragm and the bulkhead, should a break occur at the breast of the working, thus insuring the safe retreat of the workmen to the air lock in case of such an accident. The doors of the air locks are made uncommonly large and strong, both for the safety of the workmen and their convenience in passing through materials. By the use of these bulkheads, as will be readily perceived, the workmen in the other tunnel and at the shore ends of both tunnels are relieved of risk in case an

accident occurs at the working end of either tunnel. These bulkheads and diaphragms will be carried forward from time to time as the work proceeds.

The direction and immediate supervision of this important enterprise has lately been undertaken by the favorably known engineers, Wm. Sooy Smith & Son. An early beginning on the New York end of the tunnel is anticipated.

Full particulars as to the location, purpose, magnitude, and history of this great work will be found in the volumes of the *Scientific American* for 1880. For the convenience of readers, who have not the back numbers at hand, the following facts may be recapitulated:

The tunnel is intended for railway use, to obviate the expense of transferring freight and passengers for New York arriving at Jersey City from the South and West, and also to escape the delays incident to fog and ice on the river. The Hudson at the point of crossing is one mile wide. The tunnel proper (under the river) from the foot of Fifteenth Street, Jersey City, to the foot of Morton street, New York, will be 5,550 feet in length. The Jersey City approach will probably add about half a mile to the length of the excavation. On the New York side it is not decided what the course will be—whether to a terminus somewhere on Broadway or into a contemplated system of underground roads for rapid transit throughout the city.

The work comprises, as already stated, two parallel, almost cylindrical, tunnels, each 16 feet in horizontal and 18 feet vertical diameter inside. Outside the measurements are respectively about 4 feet more, the brick wall being 2 feet thick, and the outer shell of boiler iron, one-quarter inch thick. The plates of the shell are 2 feet 6 inches wide, with $2\frac{1}{2}$ inch flanges on each side, through which the plates are bolted together. The brickwork is laid with carefully tested cement. The methods of constructing the shell and laying the brick have been noticed above. In its deepest part, about 1,000 feet from the New York shore, the river is 60 feet deep. The top of the tunnel will be kept about 30 feet below the surface of the river bed. Near the New York side some rock and sand will be encountered. The rest of the way the excavation will be through the stiff clay already described.—*Scientific American*.

THE BOWER FURNACE.

In our last issue we presented illustrations and a description of the most approved form of the Barff furnace for casting iron and steel. We now present a similar series of cuts having reference to the Bower furnace. An understanding of these improved processes is of the greatest importance to stove manufacturers, and all others engaged in making ironwork, whether cast or wrought. While it is probable that the methods here described have not yet progressed beyond the experimental stage, enough has been accomplished to warrant the expectation that they will prove important elements in the manufacturing processes of the future.

The Bower furnace is somewhat more complicated than the Barff, as will be seen from the cuts. The articles are first submitted to the action of the gases of combustion, mixed with a large quantity of air, and then to the action of carbonic oxide, so that an oxidation, and later a reduction, takes place. The muffle *k*, is made of refractory brick. Gas is made in a producer of ordinary construction, *a*, Figs. 2, and 4, into a series of chambers *g*, Fig. 2, under the muffle, from which it passes through the flues *i* and *l* into the muffle *k*, Fig. 1. The gases of combustion are then conducted through *m*, Fig. 3, into a sort of regenerator, from which they issue into the chimney flue *s*. The tubes in the regenerator are made of refractory material. Into the lower tier the cold air, coming from *v*, Fig. 2, enters, and flowing through them goes through the upper tier in the opposite direction, being heated by the waste heat of the gases of combustion. This hot air ascending through *f*, Fig. 2, mixes with the gases from the generator in the chambers *g*.

The articles, after being cleaned, are charged into the muffle, and are brought to a cherry-red heat with the aid of a slightly reducing flame, obtained by allowing less air than is required for the combustion of the gases from the producer to flow into the tubes through *v*. This heating period may last from a few minutes to an hour, according to the thickness of the articles. Then an excess of air is given by opening *v* full, and the interior of the muffle becomes clear and only small flames issue from *l*. This is the oxidizing period, lasting half an hour, during which a coating of magnetic oxide is formed, and below it a layer of sesqui-oxide of iron. The air valves *v* are now closed, and the carbonic oxide from the producers transforms this lower layer,